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A LIMIT TO THE SIZE OF OCEAN STEAMSHIPS appears to have been reached in the last White Star steamers, "Cedric" and "Celtic." It is reported that the International Mercantile Marine Co. has decided to build no more of such large vessels for the present at least. The "Cedric" draws 36 ft. when fully laden, and there are very few seaports in the world where such a depth is available at the harbor entrance and in the docks at all stages of the tide.

RECENT TRIALS OF FRENCH SUBMARINE BOATS have again demonstrated their effectiveness as harbor defenders. In making an attack one of these boats repeatedly deceived the "enemy" by letting loose bottles, which were mistaken for the periscope of the "submersible," and finally a blank torpedo was fired, striking the ship upon which the attack was being made.

A TUG-OF-WAR BETWEEN TWO TUGS was held at Charleston, West Virginia, March 7. An old-style stern-wheeler, the "Lane," was pitted against a new twin screw tug, the "Rumsey," just completed by the Ward Boiler Works, of Charleston, for the Government. The "Rumsey" is provided with quadruple-expansion engines of 450 HP., and in size is about half as large as the "Lane," whose engines are also 450 HP. The "Rumsey" was easily the winner of the contest, both in pushing and pulling.

THE GREATEST FLOOD SINCE 1897 is now prevailing in the Mississippi River and the river is expected to reach a higher stage than ever before, not only from the volume of the flood but because the levees are in better condition. On March 16 a large crevasse occurred in the St. Francis levee, 20 miles above Memphis, Ark. The St. Francis levee system was described in our issue of Jan. 9, 1902. Other breaks are thought to be probable. Readers of the article above referred to and other articles in this journal—notably the valuable papers of the late Major Wm. Starling—will understand that the occurrence of crevasses is no argument against the levee system and no evidence of incapacity on the part of the engineers who who have built the levees. The levees have been built with inadequate funds and are well known to be neither so high or so strong as they should be to withstand the highest floods.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision between a freight train and a light engine near Lynchburg, Va., on the Chesapeake & Ohio R. R., on March 14. Two persons were killed and a number of others were injured. The collision is said to have been due to a misunderstanding of orders.

A BOILER EXPLODED March 16 at Toledo, Ohio, wrecking a large part of the East Toledo mills of the Republic Iron & Steel Co. One man was killed and two others injured, perhaps fatally. The top of the boiler, weighing a ton, was blown half a mile. One end of the mill was blown out. The property loss is $40,000.

THE ELECTRIC POWER HOUSE of the Bay Counties Power Co., at Colgate, Cal., was disabled on March 3 to such an extent that many mines on the Mother Lode and several towns will be without power for two months, according to local newspaper reports. The burning out of the switchboard of the Bay Counties Electric Co. substation at Cordelia is said to have short-circuited the main line, resulting in setting fire to one of the big oil transformers at Colgate. The transformer is said to have "burst," scattering pieces of wire and oil in all directions, thus short-circuiting other machines. Instantly the power house was a roaring mass of flames. This stoppage of electric power at a time when water is most plentiful means heavy loss to scores of mines and a large reduction in gold output for the state.

AN ENGINE DRIVER WAS OVERCOME by gas while running through the North Mahonoy tunnel of the Philadelphia & Reading Ry. on March 12. The press report from which we gain the information stated that the experience would probably prove fatal.

A STICK OF DYNAMITE was picked up by a boy who threw it upon the asphalt pavement on Winchester Ave., Buffalo. The stick exploded badly injuring five boys, three of whom may die.

A STEAM-DRIVEN PELTON WATER MOTOR has been successfully used by Mr. J. E. Johnson, Jr., who describes its use in "American Machinist." A tool-sharpening forge was to have a blower running at 4,500 revs. per min. with 1½ HP., and Mr. Johnson decided to try the experiment of driving this blower with steam operating a 6-in. Pelton water wheel having a bronze wheel. The steam pipe is ¾-in., the nozzle $^{9}/_{32}$-in., and the exhaust pipe 1½ ins. A globe valve controls the supply of steam, and there are no blast gates or anything else used to regulate the blast. It was predicted that the wheel would not drive the fan at the desired 4,500 revs. per min., but as a matter of fact with the valve fully opened about 10,000 revs. per min. are obtained, so that the steam has to be throttled. Mr. Johnson states that he believes the steam consumption to be less than with a reciprocating engine of like power. This Pelton water motor costs about one-quarter what a reciprocating engine costs, and has the added advantage of requiring no connecting gearing, as it is coupled direct to the fan shaft. It is suggested that a centrifugal pump might be advantageously driven in the same way, and a small motor like this might also be geared to a derrick to replace hand power in winding. There is also no reason why compressed air may not be substituted for steam.

LOCOMOTIVE CRANES to the number of 12 have been equipped with electric motors by the Manchester Ship Canal Co. The cranes travel on a track situated on the parapet of the warehouse roof. Each crane can lift 3,000 lbs. at a radius of 42 ft. A recent test of one of the cranes showed an efficiency of 82% in lifting bales of cotton. The March 6 issue of "The Iron and Coal Trades Review" illustrates and briefly describes these cranes.

PATENTS ON ALTERNATING CURRENT MOTORS issued to Nikola Tesla, Dec. 26, 1893, and now owned by the Westinghouse Electric Co., were adjudged invalid by Judge Colt in the U. S. Circuit Court, District of Massachusetts, on March 11. The patents were numbered 511,559 and 511,560 and covered what is known as the "split-phase" system by which a motor was made operative by alternating current from a single source. The applications for these patents were filed Dec. 8, 1888, and it appears that on April 22, 1888, there was published at Milan in an Italian journal a report of a lecture by Prof. Galileo Ferraris, in which the "split-phase" system was fully described. Some testimony was offered tending to show that Tesla made this invention prior to the date when Ferraris' lecture was published; but the court held it to be insufficient to establish the fact and declared the patents void by reason of the previous publication by Ferraris. The above decision was rendered in the case of the Westinghouse Electric & Mfg. Co. vs. The Stanley Instrument Co., and it follows closely the lines of a decision by Judge Townsend of the U. S. Circuit Court of Appeals on Feb. 26 in the case of the same complainant vs. The Catskill Illuminating & Power Co.

THE SIGNAL DEPARTMENT of the Chicago & Northwestern Ry. has been reorganized, and instead of the signal engineer reporting only to the chief engineer, he will report to the general superintendent on all matters pertaining to the maintenance and operation of interlocking plants, automatic block signals, electric crossing bells, etc., while he will report to the chief engineer on matters pertaining to the construction of the plant. Mr. J. A. Peabody has been appointed Signal Engineer, with four supervisors in charge of four main districts into which the road is divided. They will report directly to the signal engineer, while formerly the supervisors and repairmen reported to the division superintendent instead of to the signal engineer, which was a very unsystematic and unsatisfactory arrangement.

A NEW COAL AND PETROLEUM FIELD has been discovered on the Flat Head River, southeast of Kootenay, in British Columbia. About 300 men, mostly Americans, have located most of the territory, 220 miles having been staked out already.

GOLD MINING IN COREA, under a concession granted to an American syndicate, is described in a paper by Mr. S. J. Speak, read before the English Institution of Mining and Metallurgy. Three groups of quartz mines are now being worked and 200 stamps are in operation. The original capital subscribed by the syndicate five years ago was only enough to equip 10 stamps, and the development to the extent indicated has been made from the profits of the work so far done. The company has water transportation to within 30 miles of its mines. Most of the concentrates are treated by the cyanide process, but from one mine they are shipped to the United States. In May last the labor force employed was five white men and 192 natives, and during that month this force extracted 2,900 tons of ore and drove 366 ft. of drifts, etc. The total expenses were as follows: Five Europeans, $650; 192 natives wages, $1,350; eight surface stores, shops, coolies, etc., $1,200; total, $3,200, equal to $1.10 per ton mined on 2,904 tons. In milling and concentrating recent costs have been as follows: Tabowie Mill, 40 stamps with vanners and canvas plant:

	Tons milled.	Cost per ton.
May, 1902	4,008	42 cts.
June, 1902	4,130	40 "
July, 1902	4,589	39 "

GRANITE HAS BEEN DECLARED to be a mineral by a verdict rendered in the Supreme Court, Feb. 23, in the case of the Northern Pacific R. R. vs. J. A. Soderberg. Mr. Soderberg had been quarrying granite on a quarter-section of land claimed by the railroad as a part of their original land grant, and they sought to secure an injunction. The defence maintained that the granite was "mineral," and therefore reserved from the railroad grant. The Court has sustained this claim. In view of the meager information now at hand we are at loss to see upon what grounds granite can have been classified with the minerals to which the mineral laws apply.

AMERICAN LOCOMOTIVES FOR JAPAN to the number of 500 are said to have been exported in the past five years. The total number of all kinds in Japan is amout 1,200. English equipment was originally installed, and American firms have had to work under that disadvantage in selling to Japan. The lower price and shorter time in filling orders have been the factors in making sales.

GOLD FROM THE CANADIAN YUKON district to the amount of $80,000,000 has been won since the first great discoveries. Last year mining machinery valued at $5,000,000 was shipped to Dawson.

THE TYPHOID EPIDEMIC AT ITHACA has led to a large amount of sanitary work, actual and projected, in that city. Mr. Allen Hazen, M. Am. Soc. C. E., has been engaged by the Ithaca Water-Works Co. to make plans for a filter plant; and Cornell University, it is reported, has arranged to put in mechanical filters to treat the campus supply. Mr. Geo. A. Soper, Assoc. M. Am. Soc. C. E., has been engaged by the State Board of Health to supervise general sanitary work throughout the city, including thorough disinfection wherever needed. Investigations for a source of supply for the proposed municipal water-works are also in progress.

METHODS OF SURFACING CONCRETE CULVERTS; NEW YORK CENTRAL & HUDSON RIVER R. R., PENNSYLVANIA DIVISION.

By Geo. W. Lee, Jun. Am. Soc. C. E.*

During the past year the New York Central & Hudson River R. R. has been making extensive improvements in reduction of grades and double-tracking along its Pennsylvania Division, which extends from Lyons, N. Y., to Newberry Junction, Pa., and thence west into the coal fields of Clearfield county. The portion of this line which is along the shores of Seneca Lake, in New York State, crosses a number of deep gullies which were formerly spanned by viaducts or lattice trusses not strong enough to stand the heavy traffic now going over the road. Four of these gullies are now being filled for double-track and concrete arch culverts have been built for carrying the streams. These culverts are somewhat notable for their size, but the feature of their construction which has excited particular interest is the excellent finish of the concrete work on the visible surfaces. This finish is clearly shown by Fig. 1, which is an end view of the Dresden arch showing the filling-in progress above and the lattice girder viaduct structure which the arch and filling replace.

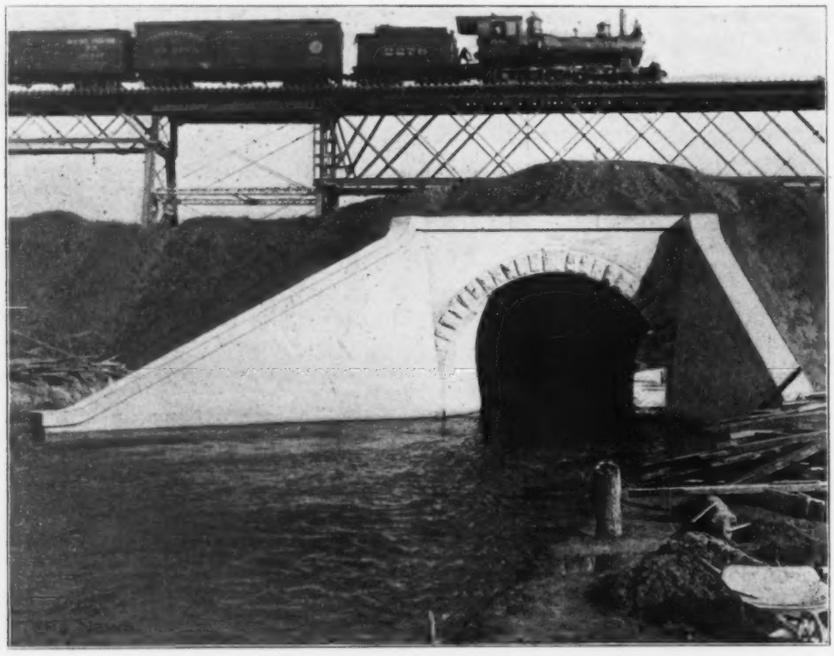


FIG. 1. VIEW OF DRESDEN ARCH CULVERT OF REINFORCED CONCRETE (25-FT. SPAN), PENNSYLVANIA DIVISION, NEW YORK CENTRAL & HUDSON RIVER R. R.
W. J. Wilgus, Chief Engineer; Sundstrom & Stratton, New York City, Contractors.

The names and main dimensions of the new culverts are given in the following tabular statement:

Name.	Length in ft.	Span in ft.	Cu. yds. of masonry.
Dresden	134	25	3,500
Ketcham Gully.	234	8	1,200
Gravel Run....	300	12	3,000
Rock Stream ..	274	16	3,000

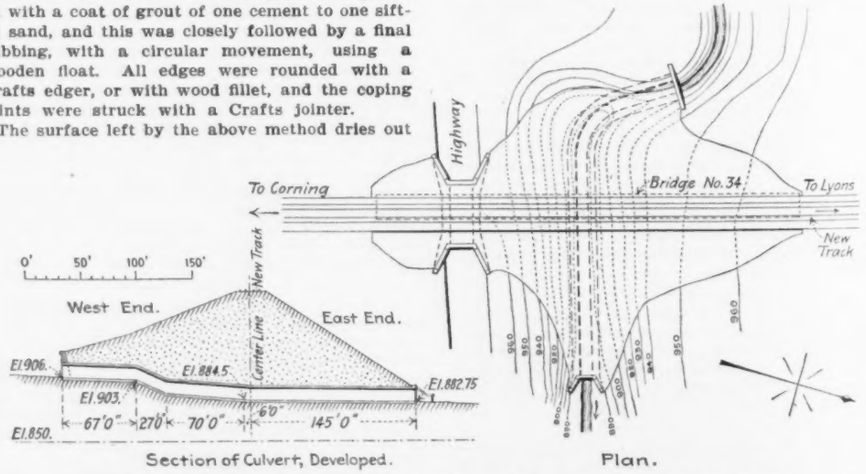
The Dresden arch rests on 600 piles driven 22 ft. to bed rock. The most interesting structurally of the four culverts is the Gravel Run, a general plan and elevation of which are shown by Fig. 2. As will be seen, this culvert is built on a sharp curve, and has a steep grade. The principal structural details of the culvert are shown by the drawings of Fig. 3, in which will be noticed an arch ring reinforcement of No. 8 galvanized wire netting of 1-in. × 2 ins. mesh, and a wing wall reinforcement of old steel rails. The highway arch adjacent to the Gravel Run culvert is 49 ft. long, with a span of 20 ft., and contains 1,000 cu. yds. of masonry. Both this arch and the Dresden arch shown by Fig. 1 have ring pens of Clearfield sandstone, which adds much to their beauty.

*Engineer for Sundstrom & Stratton, 143 Liberty St., New York city.

The method employed to secure the good surface finish, which has been mentioned, was the following: The forms of 2-in. dressed and matched pine, after being put in place, were painted with a coat of thin soft soap, then as the layers of concrete were brought up the face was drawn back with a square-pointed shovel, the edges of which had been hammered flat. Mortar in the proportion of one part cement to two parts sand, mixed rather wet, was then poured in along the form and the layer rammed against it. Hard soap was used to fill openings left by joints of the lagging. When the forms were removed and while the concrete was yet "green," the surface was carefully rubbed with a circular motion, with pieces of white fire brick or briquettes of one cement to one sand, made in molds about the size of a building brick, handles being pressed in while soft. The surface was then dampened and painted with a coat of grout of one cement to one sifted sand, and this was closely followed by a final rubbing, with a circular movement, using a wooden float. All edges were rounded with a Crafts edger, or with wood fillet, and the coping joints were struck with a Crafts jointer.

The surface left by the above method dries out to a grayish white, smooth and hard, and will not flake or peel. In hot weather it should be frequently dampened for several days to prevent the small surface cracks so often seen in concrete work. Instead of spading the face, as described, a sheet-iron form may be used, similar to that illustrated by Fig. 4, the concrete first being rammed against this, then the facing mortar poured in and the mold drawn out. When this is done a trowel should be worked rapidly along the form, to remove air bubbles.

For winter concrete work a combined water, sand and stone heater similar to that shown by Fig. 5, as designed by the writer, is an excellent thing. These heaters weigh 1,200 lbs., and can be easily handled from one job to another. They can be built for about $50. In the concrete described above, portable gravity mixers made by the Contractors' Plant Co., of Boston, Mass., were used, the deep gullies affording an ideal site for this style of mixer. The work was carried out by Sundstrom & Stratton, railway contractors, of 143 Liberty St., New York city, under the direction of Mr. R. P. Johnson, Resident Engineer for the New York Central & Hudson River R. R.



Section of Culvert, Developed. Plan.

FIG. 2. PLAN AND LONGITUDINAL SECTION OF GRAVEL RUN CULVERT.

AN IMPULSE WATER-WHEEL GOVERNED BY AN INDUCTION MOTOR.

The governing of impulse water-wheels is not as simple a matter as governing ordinary reaction turbines, and especially in the small sizes of impulse wheels there is practically no means commercially available for automatic governing. Close speed control is, however, very important in many cases, as for instance in driving dynamo-electric machinery. It will be of interest, therefore, to see how the difficulty was met in one case where the uncertainties and fluctuations of the water-wheel gave a great deal of trouble. The case was that of an exciter dynamo, supplying the field magnet coils of some large alternators; the exciter was driven by a small size impulse wheel. The means finally employed to steady the operation of the unit (wheel and dynamo combined) was simply to mount an induction motor on the same shaft with the water-wheel. An induction motor, as is well known, always runs below synchronism; when at synchronism it yields no mechanical energy, while when driven by outside means at a speed higher than synchronism, it generates current instead of consuming it, and thus returns electric energy to the supply line. In this it is quite similar to the direct-current shunt-wound motor. In the present case, therefore, the induction motor, by running above synchronism absorbed the surplus power of the water-wheel over what the exciter dynamo required, while when the load on the latter was so high that the wheel was unable to provide for it, the induction motor ceased generating current and by acting as a motor helped out the water-wheel.

By making its capacity about the same as that of the wheel, it was able to operate the exciter dynamo independently of the wheel, as when the water supply to the latter was cut off. The voltage of the induction motor being arranged to be the same as the potential across the main bus bars of the station, it supplied current to the main line when running above synchronism. The speed variation of the resultant triple unit is not great; it cannot, of course, become zero, because of the necessary increase in speed of the induction motor when changing to generator.

The case referred to is the exciter equipment in the Colgate, California, power house of the Bay

Counties Power Co. It is described in the last issue of "The Wisconsin Engineer" by Mr. L. M. Hancock, whose article we reprint in the following:

An exciter water wheel induction motor combination was originated and installed by the writer at the Colgate generating station of Bay Counties Power Company over a year ago, and has proved beyond a question its superiority for the purpose for which it was designed. Construction of the main flume had not been completed; shut downs on account of water-wheel troubles, especially on account of nozzles choking with small blocks of wood from the carpenters' saws, had become very much too numerous. The water had to be continually adjusted to suit the exciter load, which at times was changing every few minutes, and the excessive noise of the water when partly deflected from the wheel, all made it necessary to make some radical change. After careful consideration it was decided that an induction motor connected to the unit would, as a motor, take care of any disturbances on the water-wheel end and in passing from the extreme as a motor to the other extreme as a generator would control the whole unit and give us what was specially lacking, a governor.

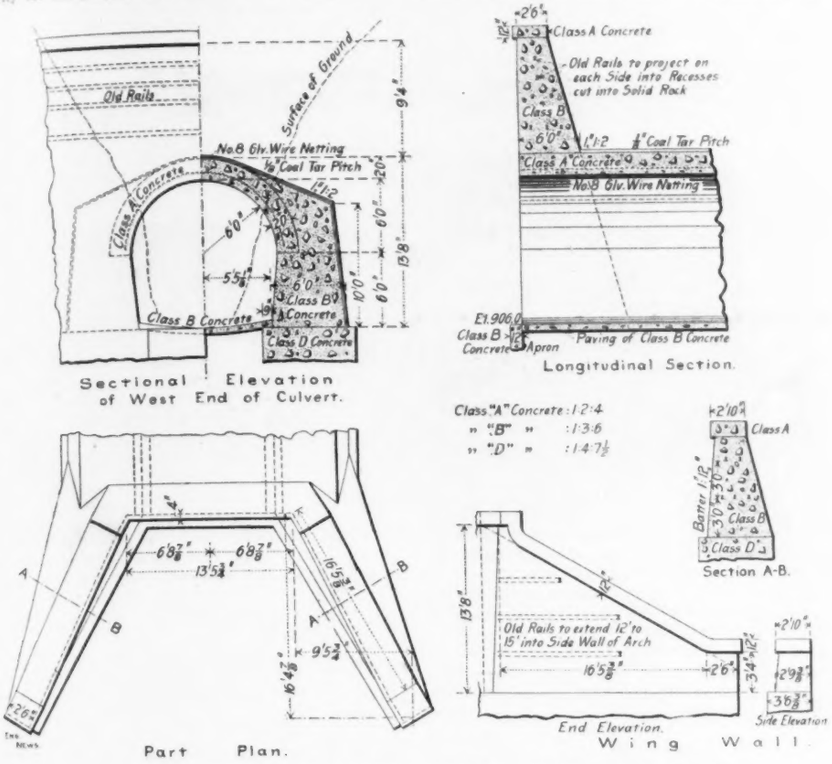


FIG. 3. DETAILS OF CONSTRUCTION OF GRAVEL RUN CULVERT.

The arrangement used is somewhat clumsy on account of adapting commercial machines to meet the conditions without making a complete new design. The operation is as follows: The unit can be started either by water or by the induction motor. If water is used, the speed of the unit is brought up to normal as indicated by a tachometer; the motor switch is closed and afterwards water is put full on the wheel. If the motor is used to start the unit, its switch is closed and the unit brought up to speed with the auto-starter, water is then turned full on the water-wheel; the induction motor, as the water strikes the wheel, changes to an induction generator, and, as the water comes full on the wheel, delivers to the station bus bars the power of the water-wheel not needed by the exciter; load can now be put on or taken off the exciter without any attention to the unit, the induction generator-motor acting as an almost perfect governor. The importance of this fact can be better appreciated when it is remembered that there is not on the market any suitable governor for small water-wheels, and that the variation in speed of a water-wheel of the Pelton type from no load to full load is nearly 50%.

The variation of the speed of the induction motor from no load to full load does not cause any serious drop in the station voltage; even should there be a serious drop in the station voltage that is infinitely better than a shut down. In fact, under the conditions as they exist with us, water has been entirely choked from the wheel by small sticks and trash without causing our customers any inconvenience and, in fact, without the station attendants knowing it, the induction motor changing from generator to motor instantly, and going ahead with the load until the water-wheel nozzle was found choked and could be cleaned.

We are so well pleased with this method of driving our exciters that we are installing, in a new 8,000-KW. power house now building, a specially designed duplicate exciter outfit, which is to have the exciter and induction motor on the same bed plate with three bearings; the water-wheel to be overhung at one end of the induction motor, which is wound for the bus-bar voltage of the station, thus making a very simple, compact and complete exciter outfit.

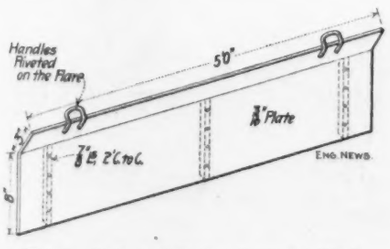


Fig. 4. Facing Mold for Concrete Work.

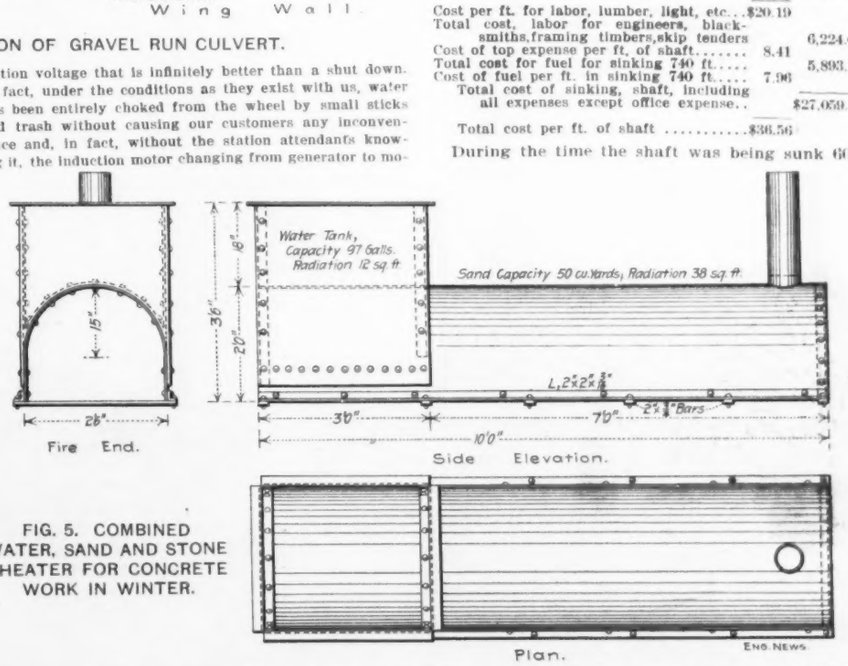


FIG. 5. COMBINED WATER, SAND AND STONE HEATER FOR CONCRETE WORK IN WINTER.

COST OF SHAFT SINKING AND DRIFTING AT THE LINCOLN GOLD MINE, CALIFORNIA.

The cost of sinking the Lincoln shaft at Sutter Creek, Amador county, California, is given in detail in the fifth annual report of Mr. E. C. Voorheis, Superintendent of the Lincoln Gold Mine Development Co. Mr. Voorheis has courteously given us certain additional data not contained in the regular report as follows:

In shaft sinking the men work 8-hr. shifts, but in drifting 10-hr. shifts. The average depth of each drill hole in shaft sinking is about 6 ft., but in drifting 5 ft. The drilling was done by power, using the "Baby" giant drill manufactured by the Compressed Air Machinery Co., of San Francisco. The powder used was Hercules, 40% nitroglycerin, and the fuel for steaming was crude oil delivered at the mine at $1.50 per bbl, of 42 gallons.

COST OF SHAFT SINKING.

The work of sinking the Lincoln shaft was completed May 24, 1902, sinking from a level of 1,260 down to the 2,000-ft. level, a distance of 740 ft.

The size of the excavation is 8 × 17 ft. Material encountered in sinking, greenstone and hard black slate.

The labor cost of sinking and putting in timbers was as follows: It required 3,864 blasting holes drilled in the bottom of the shaft, or 5.2 per foot of shaft, which took:

2,956 days' labor at $2.75 per 8-hr. day		$7,129.00
1 day foreman, 350 days, at $4		1,400.00
1 night foreman, 282 days at $3.25		916.50
Total labor cost of sinking 740 ft. and putting in timbers		$9,445.50
Labor cost per ft. for sinking 740-ft. shaft	$12.76	
12,450 lbs. Hercules powder used, costing		1,307.25
Cost of powder per ft. of shaft	1.76	
Amt. of powder per ft. of shaft, 16.8 lbs.		
35,800 ft. of fuse used, costing		125.30
Cost of fuse per foot of shaft	.17	
Amt. fuse per ft. of shaft, 48.4 ft.		
46 boxes of Lion caps were used costing		46.00
Cost of caps per ft. of shaft,	.06	
2,400 lbs. of candles used, costing		288.00
Cost of candles per ft. of shaft	.39	
Amt. candles used pr ft. of shaft, 3.2 lbs.		
148 sets of timbers, requiring 207,200 ft. of lumber; average cost $18 per M		3,729.60
Cost of lumber per ft. of shaft	5.04	
Amt. lumber per ft. of shaft, 280 ft.		
Total cost, labor, lumber, light, etc.		$14,941.65
Cost per ft. for labor, lumber, light, etc.	$20.19	
Total cost, labor for engineers, blacksmiths, framing timbers, skip tenders		6,224.00
Cost of top expense per ft. of shaft	8.41	
Total cost for fuel for sinking 740 ft.		5,893.50
Cost of fuel per ft. in sinking 740 ft.	7.96	
Total cost of sinking, shaft, including all expenses except office expense		$27,059.15
Total cost per ft. of shaft	$36.56	

During the time the shaft was being sunk 60,025 tons of water were hoisted, or 14,406,200 gallons.

9,456 tons of waste were hoisted from the bottom of the shaft to the surface, which added to the water would make a total of 69,481 tons hoisted to the surface during the time the shaft was being sunk.

COST OF DRIFTING AND CROSS-CUTTING.

On July 1 we commenced cross-cutting for the vein channel, starting from the north side of the shaft and gradually turning to the west, until we

reached a point at right angles to the foot wall of the shaft, which is at right angles to the formation of the ground. This cross-cut has been extended in a westerly direction 642 ft. At a point 187 ft. west of the foot wall of the shaft we passed through a fissure of soft black slate, 40 to 60 ft. wide, carrying a good deal of water on the hanging wall side and some stringers of quartz, which we suppose is the channel that carried the ore bodies on the upper levels. We drove north on the foot-wall side of this fissure 233 ft. and south 250 ft., making in all 483 ft. driven on the channel. At the end of each drift we cross-cut both east and west 12½ ft. each way, which is room enough to run cross-cuts with the diamond drill.

We have rented a diamond-drilling outfit, and expect it to arrive at the mine any day, which we will immediately put to work, as we can prospect much faster and cheaper with the diamond drill than by tunnelling.

The following is a detailed statement of the cost of running 1,175 ft. of drifts and cross-cuts on the 1,950-ft. level. Most of the rock was hard greenstone; average size of tunnel, 5 × 8 ft.:

1,428 days' labor,*		$3,772.50
168 days for day foreman at $4		672.00
134 days for night foreman at $3.25		435.50
Total labor cost for drifting and cross-cutting 1,175 ft.		$4,880.00
Average labor cost per ft.	$4.153	
11,150 lbs. of powder used, costing		1,226.50
Average cost of powder per ft.	1.043	
26,500 ft. of fuse used, costing		79.50
Average cost of fuse per ft.	.008	
35 boxes of Lion caps used, costing		35.00
Average cost of caps per ft.	.03	
800 lbs. of candles used, costing		96.00
Average cost per ft. for candles	.082	
Total cost per ft.	$5.376	
Total cost		$6,317.00

3,258 blasting holes were drilled.
Average number of holes drilled per ft., 2.77.
The average amount of powder used for each blasting hole was 3.42 lbs.
Average amount of fuse per ft., 22 ft.; average number of caps per ft., 3; average amount of candles per ft., 0.68 lb.

*Miners at $2.75 per 10-hr. day, and car-men at $2.50

WATER-POWER ELECTRIC PLANT AT MANCHESTER, CONN., FOR THE CHENEY BROS.' SILK MILLS.

By Earl E. Boardway.*

About nine miles east of Hartford, Conn., is situated the thriving village of South Manchester. Here is located the immense silk mills of Cheney Brothers, the largest establishment of its kind in New England.

Steam, until recently, has furnished all the power for these silk mills, but early in 1901 the Cheney Brothers bought up three dilapidated powers of 8 ft., 10 ft. and 22 ft. fall on the Hockanum River at Manchester, Conn., and engaged Mr. A. C. Rice, M. Am. Soc. M. E., of Worcester, Mass., to take these three water privileges and deliver their power to their mills in South Manchester, about three miles distant. Mr. Rice accordingly made plans to consolidate these falls into one and control the water supply in one pond.

*State Mutual Building, Worcester, Mass.

FIG. 1. CONCRETE DAM ON THE HOCKANUM RIVER AT MANCHESTER, CONN.

To accomplish this it was necessary to raise the elevation of one of the old dams and conduct the water by a steel feeder pipe to the site of the power house on the fall farthest downstream. The old dam was a stone structure erected many years ago and crowning upstream in the shape of a slight arch. It was found necessary to remove a few of the top courses and to thoroughly clean the exposed faces and joints of the old masonry before applying the new concrete. Thus a concrete dam was constructed 30 ft. high, with an ogee face, by using the old masonry as a core wall and adding a new concrete apron and roll-way, and sealing the back by a thick layer of concrete.

The dam runs across the river for a distance of 130 ft., and then turning an angle runs parallel to the river for 210 ft. to the waste gate abutments and gatehouse. From the gatehouse a dike 10 ft. high runs back 160 ft. to the natural level. The gatehouse covers the entire forebay and racks, as well as housing the gate irons. A steel bulkhead, with three wooden head gates, shuts out the water from the portion of the forebay leading into the penstock. Slat flooring in the gatehouse admits air to this chamber and thus relieves the pipe when the head gates are closed.

The waste gates on the dam are operated by an ingenious mechanism, designed by Mr. Rice, by which one man can with ease operate them. The gate stem, instead of having a rack and pinion, consists of a single rod threaded to run through a nut resting on ball bearings in the head of the apparatus, which is operated by gears and crank, the working parts being encased and protected from the weather.

From the gatehouse the feeder pipe 9 ft. in diameter, built of 5-16-in. steel and single riveted, runs downstream along the river bank for a distance of 2,700 ft. to the power house. Two lap expansion-joints were provided to take care of the expansion and contraction, as a large part of the pipe lies half exposed above ground. For the first few hundred feet the pipe lies on the bottom of the old canal that supplied water to the abandoned mills along the river, and here it has been entirely buried.

Just before the water reaches the wheels it passes through a stand-pipe 12 ft. in diameter and 50 ft. high, which stands near one corner of the power house. It is built of 5-16-in. and ¼-in. steel. The stand-pipe was necessary to relieve the feeder pipe, which is so long that the sudden changes of load upon the water wheels would

FIG. 2. WASTE-GATE HEADS ON MANCHESTER DAM.

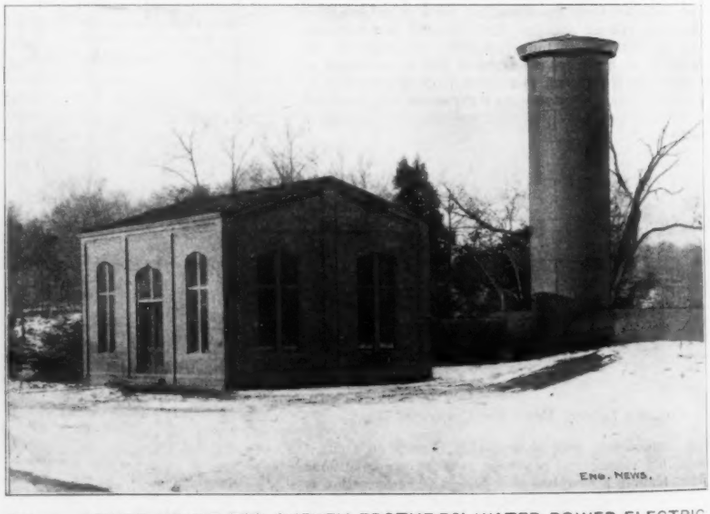


FIG. 3. POWER HOUSE FOR CHENEY BROTHERS' WATER POWER ELECTRIC TRANSMISSION, SHOWING STAND-PIPE AT TERMINUS OF 2,700 FT. PIPE LINE.

otherwise produce great strains upon the pipe caused by water hammer.

The top of the stand-pipe is 10 ft. above the crest of the dam, and has a wood roof covered with standing-seam steel roofing. In the side of this stand-pipe, at a level 1 ft. above the crest

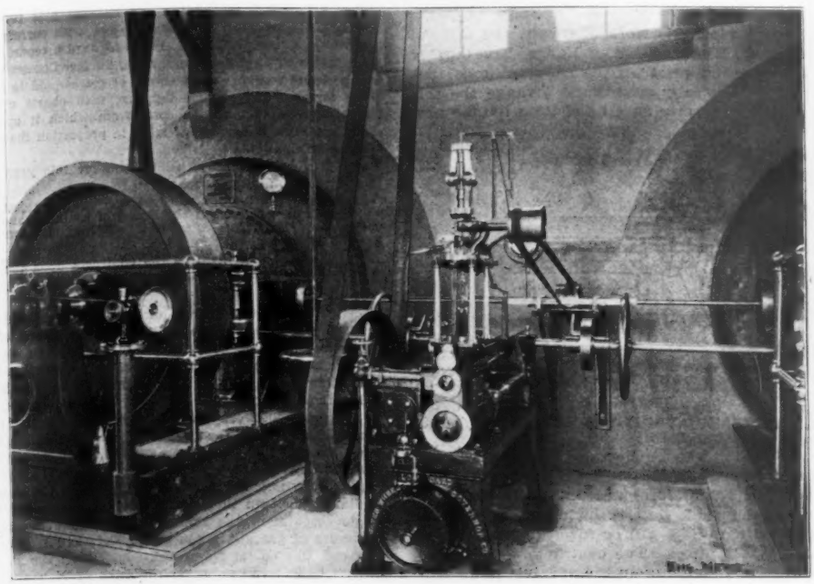


FIG. 4. LOMBARD GOVERNOR CONTROLLING TWO WATER-WHEEL UNITS IN POWER HOUSE.

of the dam, is a waste pipe 36 ins. in diameter extending down the standpipe and into the river. The object of this waste pipe is to prevent any oscillation of the water in the stand-pipe caused by the action of the governor.

From the stand-pipe the water passes into the flumes of the two wheel units, which are erected on steel beams and concrete piers in the rear of the power house directly over the tailrace, so only the flume head projects into the power house.

The power house is a neatly constructed brick structure 32 × 48 ft. The roof is covered with standing-seam steel roofing laid on 2-in. planking planed and beaded on the under side. The purlins supporting this planking are also finished and are carried by two steel trusses, the bottom chord of which is 20 ft. clear of the floor.

The floor consists of six inches of concrete dressed on top with a finish coat of neat cement. The generator foundations are large blocks of concrete, and the tailrace walls are also concrete.

The water wheels, designed specially by Mr. Rice, consist of two pairs of 24-in. horizontal turbines, rated at 510 HP. each, with a speed of 327 revolutions under a head of 36 ft; although the total head is 40.5 ft., an allowance is made to draw the storage pond 4.5 ft.

On the shaft of each wheel is a momentum wheel 6 ft. in diameter, weighing 5,250 lbs. and built of steel plates riveted together. It is guarded by a brass railing.

In the governing apparatus of the water wheels, a novel feature has been introduced. One Lombard governor, type D, is used to govern the two wheels, whether only one of the two or both are running together. The governor is placed centrally between the two wheels. An overhead shaft with specially designed friction clutch pulley at each end, is driven by a quarter twist belt from each wheel. This shaft drives the pump of the governor, and as the friction pulleys are connected to the same shifter, which is operated by a hand wheel on a vertical rod standing near the governor, the shaft is driven by merely throwing out the friction pulley driven by the wheel that may happen to be not running. A smaller shaft on a level with the wheel shafts and behind the governor is used to drive the speed balls of the governor. This shaft is divided in the middle and each part is driven by a small belt from the shaft of each wheel in a similar way to the pump shaft. The governor balls are driven by a belt that can be shifted from one part of this shaft to the other. It was found necessary to have these two separate shafts, as the jerking of the pump interfered with the driving of the sensitive speed balls.

The gate shaft passes through the governor to the racks of each wheel and has a special lock coupling to disconnect the part operating the gates of the idle wheel.

A hand wheel on each part of the gate shaft is used to open the gate of each wheel if one or the other should not be running; then if more power is required and the second unit is to be started the gates of the idle wheel are opened by means of the hand wheel to the same opening of the first wheel, and the gate shafts connected by means of the lock coupling, when the governor immediately takes hold and regulates the gates to the required load. It is, of course, understood that the generators are connected on the switchboard when they are in synchronism and run in parallel to carry the whole load.

Each water wheel is direct connected to a Westinghouse three-phase revolving field alternator delivery 300 KW. of current at 6,600 volts.

The exciter is mounted on the free end of the generator shaft, and is thus driven at the same speed as the generator. The exciters are 25 KW., 125-volt machines. One exciter is capable of exciting both generators if the other exciter is disabled.

The lightning arresters are grounded to the penstock. The transmission line is about three miles long, and consists of three strands of copper wire and runs to the Cheney Brothers' mills in South Manchester. Here the 6,600-volts alternating current is transformed to 440-volts direct current and is used to light the entire plant and drive the machine shop, carpenter shop and velvet mills. Additional motors will be installed till the available current is all utilized. The present steam plant will be kept as an auxiliary to furnish power during periods of low water and heavy loads.

David Waite, of Holyoke, Mass., was the contractor for the concrete dam, the gatehouse, dike and power house. The American Bridge Company built the steel bulkhead and racks. The Riter-Conley Mfg. Co., of Pittsburg, Pa., erected the feeder pipe and stand-pipe. The Eastern Bridge & Construction Co., of Worcester, Mass., furnished the structural steel work for the power house. The Stilwell-Bierce & Smith-Vaile Co., of Dayton, Ohio, built the water wheels with the draft tubes and momentum wheels complete to the generator coupling. The Lombard Governor Co., of Boston, Mass., furnished the water wheel governor. The Westinghouse Electric & Manufacturing Co., of Pittsburg, Pa., furnished the entire electrical equipment.

A. C. Rice, Consulting Engineer, of Worcester, Mass., was designing engineer, and G. R. Stattlemann, of Dayton, Ohio, was resident engineer.

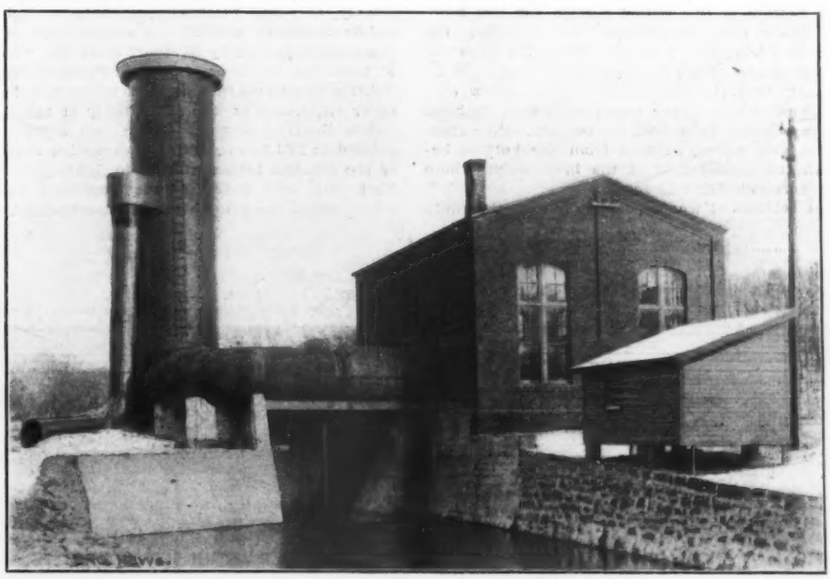


FIG. 5. VIEW OF POWER HOUSE FROM TAIL RACE, SHOWING DRAFT-TUBES AND WASTE OVERFLOW FROM STAND-PIPE.

THE WORKING OF OIL SEPARATORS has been investigated by Mr. C. Bach, who finds that the quality of oil used has a great effect on the amount of purification obtained. Two different grades of oil used in the cylinder of an engine showed the following results in a separator placed in the exhaust pipe: Oil No. I., amount of oil in the exhaust before purification 0.0105%, after passing through separator 0.0025%; Oil II., before purification 0.0280% oil, after purification 0.0005% oil. The respective degrees of purification were 76.2% and 98.3%. In the former case the condensation water was noticeably milky, while in the latter case it was quite clear. On analysis the two grades of oil showed a great difference in the percentage of saponifiable fats which they contained. Thus, Oil I. contained 2.44%, Oil II. only 0.01% saponifiable fat; in the case of Oil I. this fat was quite similar to tallow. Mr. Bach concludes that the great amount of this tallow-like fat in Oil I. was responsible for the poor degree of separation produced by the separator; the action, he thinks, is due partly to the emulsion-forming ability of this fat, and partly to its decomposition by the steam and the subsequent formation of calcium soaps with the lime contained in the water.

THE ACCIDENT TO THE BUFFALO BREAKWATER.

During the severe storm of Dec. 10, 1902, there occurred a serious settlement of a portion of the stone or rubble mound section of the U. S. Government breakwater at Buffalo Harbor, New York. Altogether some 1,300 ft. of the breakwater settled from 10 ft. to 14 ft. into the underlying clay, and will have to be repaired. The original structure was fully described in Engineering News of May 16, 1901. Fig. 1 is a typical cross-section of the breakwater as constructed, and in connection with this we show a typical cross-section (Fig. 2) of the injured portion, which has been furnished us by Maj. T. W. Symons, Corps of Engineers, U. S. A., under whose direction the breakwater was built.

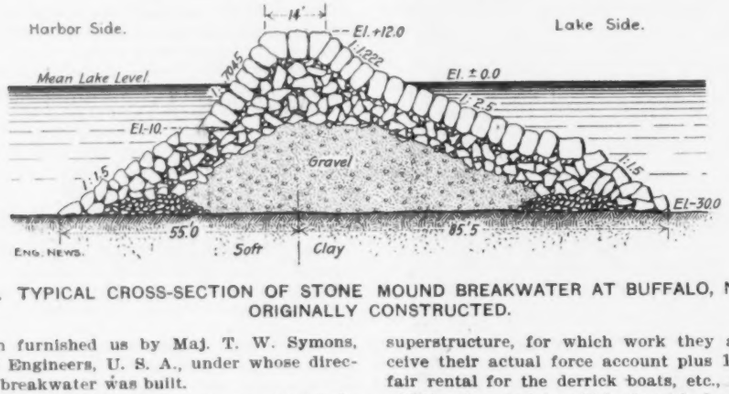


FIG. 1. TYPICAL CROSS-SECTION OF STONE MOUND BREAKWATER AT BUFFALO, N. Y., AS ORIGINALLY CONSTRUCTED.

In making the original estimates for this breakwater it was expected that the whole structure would settle into the underlying mud, and the quantities in the estimate provided for a settlement of about 10 ft. at the edges and 15 ft. in the center of the structure. As the work proceeded it was found that the expected settlement did not take place, the total settlement at any place not exceeding a foot or two. On Dec. 10, 1902, when but three days more were required to complete the entire 7,261 ft. of the breakwater, a length of about 1,000 ft. near the southern end sank 10 to 14 ft. into the clay during a violent storm. Five days after 300 ft. more, just south of the other section, went down.

The portion that went down was built during the past season, 1902; and the inference is that the clay bottom at the settled portion has less bearing power than that to the north, where the structure has stood without settling for from one to five years. This inference is strengthened by the fact that the preliminary borings show that the mud beneath the standing parts contains strata of sand, hard sand, gravel, etc., while these strata are entirely absent from the bottom beneath the settled part of the breakwater where only soft red clay was found.

The settlement was a peculiar one, in that only the rear portion of the breakwater settled, leaving the front from the water line lakeward in place and apparently undisturbed. The accompanying section, Fig. 2, shows the structure as it now is, and as it is proposed to rebuild it. The movement was apparently a settling and sliding landward under the pounding of the terrific seas and yielding of the clay bottom.

In repairing the settled portion of the breakwater it is proposed to place rip-rap along the harbor slope to make it about equal to the lake slope. All the capping stones of the sunken portion which can be conveniently gotten at, particularly the angle stones, are to be removed and used again in the new superstructure, after the rubble foundation has been rearranged. To add to the security of the entire structure it is also proposed to place rubble stone along the inner slope, thus widening out the harbor toe.

In performing this work of repair, the original contractors, Hughes Bros. & Bangs, have agreed to take up and reset all the capping stone that can be economically saved, and arrange the settled portion properly as a foundation for the new superstructure, for which work they are to receive their actual force account plus 15% and a fair rental for the derrick boats, etc., used. All additional materials will be furnished at the original contract prices. The contractors will begin the work of rebuilding on the opening of the season, and it is expected that the entire structure will be completed early in the summer of 1903.

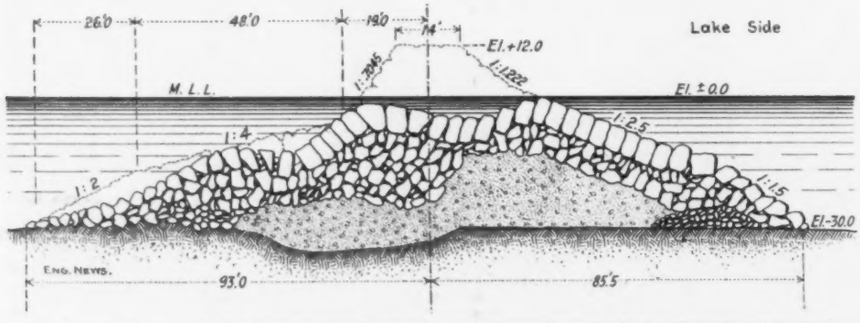


FIG. 2. TYPICAL CROSS-SECTION OF BUFFALO BREAKWATER AFTER SETTLEMENT HAD OCCURRED.

Before the meeting of the Board of Estimate and Apportionment closed, Mayor Low was authorized to draft a bill for submission in the legislature, authorizing the city to build a plant to supply electric current for lighting its streets and public buildings, and also authorizing it to make a ten-year contract for lighting, with the privilege of revising the terms every 2½ years. It was also voted to secure a report from an electrical engineer on the cost of a municipal lighting plant. On the following day, Mr. Cary N. Hutchinson, M. Inst. E. E., a consulting engineer, of 71 Broadway, New York city, was engaged for the purpose just named. The two reports already mentioned are as follows:

STREET LIGHTING CONDITIONS IN NEW YORK CITY AND A PROPOSED MUNICIPAL PLANT.

With a surprising suddenness and unanimity the Board of Estimate and Apportionment of New York city, on March 12, took steps which seem destined to result in either municipal ownership of the public lighting service of the city or else a marked reduction in the cost of the service supplied by private companies. On the date named Mayor Low submitted to the board a report from Mr. Robert Grier Monroe, Commissioner of Water Supply, Gas and Electricity, on bids for lighting public buildings and streets during the current year, accompanied by a report from Mr. Charles F. Lacombe, Engineer of Surface Construction, on lighting conditions in New York as compared with other cities, and on the advisability of municipal public lighting service. These two reports are printed in full below, with the exception that two of the detailed tables relating to lighting in New York city, and a few of the comments on the tables which we print herewith, are omitted.

Hon. Seth Low, Mayor of the City of New York and Chairman of the Board of Estimate and Apportionment.

Sir: I herewith transmit a summary of bids received for public lighting for the current year, with corresponding prices for the year 1902. I also forward a report from Mr. Charles F. Lacombe, Engineer of Surface Construction, which report contains a statement of prices paid in other cities for gas and electric lighting, with charts clearly indicating the comparative cost, from which it appears that New York is paying far more in proportion than any other municipality.

The proposals issued to all bidders for this year contain the following paragraph:

20. The Commissioner reserves the right to reject any or all bids or estimates if the Board of Estimate and Apportionment shall determine it for the public interest of the city so to do.

I am unwilling to execute the contracts upon the bids submitted and I recommend in the interest of the public that all bids be rejected.

Section 530 of the charter directs that such contracts shall be made after public bidding, and for a term of not exceeding one year. That section is taken from Section 537 (Chapter 378) of the Charter of 1897, and must have been drawn originally to meet then existing conditions, and with the expectation of securing actual competition in the prices between rival companies operating in the same field. Within the past five years the lighting interests in this city have all practically united, and even in those boroughs where there has been no formal consolidation the territory has been apportioned. In the Borough of Manhattan both illuminants have been absorbed by a single corporation and there is no rivalry even between producers of gas and producers of electricity. The Consolidated Gas Co. of New York controls all the gas and electric light facilities in the Borough of Manhattan, as well as all gas and electric light facilities in the more important sections of the Borough of The Bronx. As far as gas light is concerned, not only does the price remain fixed, but all improvement in the utilization of gas is retarded.

A wide extension of street lamps provided with incandescent mantles is greatly needed. By this method the same consumption of gas produces three times the illumination given by the open burner. It costs Chicago $2.40 a year additional for a lamp with an incandescent mantle. It costs the Borough of Manhattan $11.50 additional, and for the same improvement we must pay $15 a year in Brooklyn. The Consolidated Gas Co. agrees to furnish the ordinary street lamp with open gas burner at $17.50 per year, and its bid for gas lamps with mantles is $20 per lamp per year. Neither the Standard Gas Light Co., nor the New Amsterdam Gas Light Co. (both controlled by the Consolidated Gas Co.), bids for incandescent gas lights. Both agree to furnish the ordinary gas lights for much less than $17.50, the Standard for $13.04½ per lamp per year, and the New Amsterdam for $12. Their bids are for such lights as are or may be on the line or lines of their mains. These comparatively low bids are induced by restrictions in their charters; but the city is virtually prevented from getting the benefit of these lower bids as far as incandescent or mantle lights are concerned. If it is desired to substitute on a Standard or New Amsterdam lamp an incandescent burner for the ordinary open burner, it is necessarw to transfer the lamp from the mains, or to speak more accurately from the books, of one of those companies to the books of the Consolidated Gas Co., paying, of course, the latter company's price.

On the Chicago basis of prices we could save enough on the 5,500 high-priced Welsbach lamps in use in Manhattan and The Bronx to change 20,000 ineffective open-flame burners to incandescent mantle lights, improving the illumination of our poorly lit streets in those boroughs 100% and saving $40,000 of the present appropriation.

In The Bronx the Central Union Gas Co. (controlled by the Consolidated Gas Co.) bids $22 for the open-flame lamp; the Northern Union Gas Co. (controlled by the Consolidated Gas Co.) and the Westchester Lighting Co. (controlled by the United Gas Improvement Co. of Philadelphia) each bids $24, but each of these three bids covers a distinct and separate district. These exorbitant prices so nearly alike present an analogous situation to that which existed in 1876 when Hon. William C. Whitney, then Corporation Counsel, advised the Mayor that there was conclusive evidence of collusion, and when as a result of the rejection of all bids a subsequent agreement was made by the same companies as had previously bid to supply the city at greatly reduced rates. The Bronx Gas & Electric Co. puts in no bids for gas lights, and finds itself with no opposing bids for electric lights in the section it covers. An analysis of the bids in other boroughs does not show any keener competition. No independent gas company in any district has bid against another independent gas company; no independent electric light company has bid against another independent electric light company. In the entire five boroughs there have been no opposing bidders for supplying the same class of light to the same district—unless we may consider the Welsbach Co., which has put in a bid, but higher than

that of the Consolidated Gas Co., for its own "Welsbach" mantle lights.

In 1895 the courts held that the provision of law requiring that contracts for work or supplies must, after presentation of sealed bids, be given to the lowest bidder, was not applicable to the Harlem Gas Light Co., because it had a monopoly. Judge Monell said (3 Rob. at pp. 121-2):

It is not perhaps too much to say that in every species of work or supplies which can be *competed* for it is the duty of the corporation to invite proposals, and to give the contract to the lowest bidder. But where there is no *possibility* of competition, and in respect to whose manufacture one company has the complete monopoly, it seems to me that the provisions of the charter cannot be deemed to apply, and therefore impose no duty. The law must have a reasonable construction. If the object in a given case fails of accomplishment, the law construed by its intention must also fail. To advertise for proposals for a supply of gas in a district exclusively occupied by one gas company, would be a practical *absurdity*. It would enable that company to propose for the supply at a price much beyond the fair value, and its single bid (under the charter of 1861) would entitle it to the contract at the price named, thus defeating the end designed, to secure the city from favoritism and jobbing.

It is not necessary to deny that illuminating gas comes under the denomination of *supplies*; but the word in its application to the subject of contracts must be restricted in its signification and meaning to supplies which are, or may be the subject of a general competition, and which can be furnished by more than one person or company. Any other meaning given to the word would impute to the legislature the design of scheming with contractors to defraud the corporation rather than an intention to protect its public treasury.

Judge Porter said (33 N. Y., at pp. 324-5):

In the present case, an adoption of the construction claimed by the municipal authorities would lead to the absurd conclusion, that the legislature designed to force a provision into the city charter, compelling the corporation to pay whatever price the sole bidder might choose to exact in his sealed proposals, for the use of property in which he has an absolute monopoly, and in relation to which there can be no competition within the range of legal possibility.

Moreover, in my opinion the provisions of section 530 of the charter are too inelastic to permit the city being effectively benefited by competition, were actual competitors in the field. The term of one year is also too short a period for an advantageous contract.

I, therefore, recommend that section 530 of the charter be so amended that the Commissioner of Water Supply, Gas and Electricity may make such contracts without public bidding and for a term of not exceeding three years when authorized by the Board of Estimate and Apportionment. If these amendments be passed the Board of Estimate and Apportionment can consider all questions relating to the cost of manufacture and distribution of the supplies under consideration and contracts fair to both parties can be entered into.

The appropriation for all public lighting for this year, 1903, is $3,306,346. The corresponding appropriation in 1898, the first year of Greater New York's existence, amounted to $2,570,002. The increase in five years has been $736,344, or between 28 and 29%. Notwithstanding this increase, the sum appropriated this year, in view of the prices asked, is entirely inadequate to meet the reasonable requirements of the city. There can be little improvement in the densely populated sections which are now insufficiently lighted, and large areas which have recently been improved must for the time being be left without any lights at all.

The growth of the city, the many public improvements which are now under way, as, for example, the new bridges which are rapidly nearing completion, all mean a great increase of public lighting; and unless there is a material reduction in prices the annual appropriation five years hence must necessarily equal or exceed $5,000,000.

I have called your attention to the fact that the mantle or incandescent gas light is a great improvement over the old open burner. Electricity is the illuminant, however, of the greatest importance for public lighting. Sixty per cent. of our entire appropriation for this year, or about $2,000,000, will be expended for electric lights.

In the borough of Manhattan the price bid for a 2,000-c. p. lamp is $146. The price in Brooklyn for a 1,200-c. p. lamp is $124.50. I have secured from 68 cities throughout the country the prices paid to the various electric light companies for supplying these cities with 2,000-c. p. lamps, and the average price is $88.60. In 23 other cities using 1,200-c. p. lamps the average price is $81.08. The combination which now imposes exorbitant prices upon New York is formidable, but to my mind its strength is more apparent than real.

The capitalization of the electric light companies in our city may be best exemplified by the New York Edison Co. It is now capitalized at $45,200,000 in stock, subject to $40,138,000 bonds, making the total $85,338,000. The original company, the Edison Electric Illuminating Co., which seems to have had a fairly conservative management and capitalization ($9,200,000 stock subject to $6,500,000 bonds) was bought by a syndicate early in 1899. This syndicate at the same time bought the bonds and stock of certain comparatively small companies, and then turned the whole over to the newly formed New York Gas & Electric Light, Heat & Power Co. for $28,500,000 bonds of that company and $36,000,000 stock. Shortly thereafter the illuminating and power companies consolidated with each other by adding the $9,200,000 of Illuminating Co. stock to the $36,000,000 Power Co. stock, and forming the present New York Edison Co. The original nominal capital, which was increased to the present figures by this legerdemain, was as follows:

Edison Electric Illuminating Co., bonds	$6,500,000
Edison Electric Illuminating Co., stock	9,200,000
Mt. Morris Electric Light Co., bonds	988,000
Mt. Morris Electric Light Co., stock	1,500,000
North River Electric Light & Power Co., bonds	104,000
North River Electric Light & Power Co., stock	400,000
New York Light, Heat & Power Co., bonds	320,000
New York Light, Heat & Power Co., stock	375,000
Borough of Manhattan Electric Co., stock	100,000
Manhattan Lighting Co., bonds	250,000
Manhattan Lighting Co., stock	250,000
Block Lighting & Power Co., No. 1., stock	98,000
Yonkers Electric Light & Power Co.,* bonds	200,000
Yonkers Electric Light & Power Co.,* stock	190,100
Consolidated Tele. & Elec. Subway Co.,* bonds	4,225,000
Consolidated Tele. & Elec. Subway Co.,* stock	1,514,000
Cash contributed by Power Co. from proceeds of mortgage	4,000,000
Total	$30,214,100

*There is a minority interest of $9,900 Yonkers stock and $359,000 Consolidated Subway stock outstanding.

An analysis of the figures in this table will show, however, that they are altogether too high, and that the original nominal capital was itself very much inflated. The figures given for the Edison Electric Illuminating Co. are probably not far out of the way. No account is taken of the very great depreciation in the values upon which the capitalization had been originally based (particularly by reason of the abandonment of a number of stations), but on the other hand this was probably offset by a surplus reported to the stockholders of about $2,800,000 at the time of the consolidation. The Mt. Morris Co., however, was barely earning the interest on its bonds, so that its stock was probably practically worthless; the Borough of Manhattan Co. was an operating concern with no plant of its own; the plants of the Manhattan Lighting Co. and the Block Co. had been abandoned; while the bonds of the Consolidated Subway Co. had been issued at a considerable discount, and its stock, as I am informed, either without consideration or in consideration of patent rights now of no value.

This enormous valuation is based upon the profit permitted by the present monopoly system. Modern improvements, especially in the concentration of the work of producing power (which, incidentally, as above stated, caused the abandonment of so much of the original plant of the company) have so rapidly decreased the expense that while the cost to the company per kilowatt hour of current delivered is known to have been over 5 cts. in 1900, and about 4½ cts. in 1901, there is good reason to believe that it has since been reduced to about 3 cts. I do not find, however, that there has been a corresponding reduction in prices. The bills presented to the department for lighting public buildings for January, 1903, show that the city is charged upon an average at the rate of 10.15 cts. per KW. hr.

There can be no question but that the capitalization of the Edison Co. represents several times the value of its plant. If the city of New York would undertake to supply itself with electric light, its interest charges would be limited to the amount actually expended on its plant and it would not be burdened with the necessity of declaring dividends on watered stock. In the Borough of Manhattan the electrical conductors would be carried through the existing subways without incurring any expense by way of rental for the space occupied. These subways are divided in ownership between two subway companies, but each of them is bound by its franchises to

without charge supply to the city of New York all space in said subway necessary for its electrical conductors and the electrical conductors of each separate department of said city which may now or hereafter be required.

I am informed by officers of the Edison Co. that the subway rentals for electrical conductors which are now used for city lights amount to $100,000 a year. If the city had an electric light plant the cost of distribution would be reduced by that amount.

The total cost to the New York Edison Co. for generating and distributing electrical energy is, as I have stated, probably less than 3 cts. per KW. hr. for energy delivered at the lamp terminal. A pair of lamps such as are used on Fifth Ave. take about 750 watts and consume in one year on the basis of 4,000 hours burning, 3,000-KW. hrs., costing $90, equal to $45 per lamp. This figure is probably in excess of the actual cost. The difference between $90 and $182.50 (the bid per pair of 900-c. p. lamps) equal to $92.50, includes maintenance of the lamps, interest on the investment and profit. The total cost of maintenance per lamp should not at the outside be $10. The system used by the Edison Co. is the direct-current enclosed-arc system and it is used by them not because it is the most economical for street lighting, but because it fits in with other requirements—that is to say, with general commercial uses. On this system there is the loss in resistance of about 40% of the energy delivered to the lamp. The city can adopt a system by which this loss can be largely saved.

The city of New York would have, therefore, three definite advantages over such a company as the New York Edison Co. in supplying electricity for public uses:

(a) Low interest payments based on loans measured by funds actually required for construction as distinguished from the fixed charges which burden an inflated capitalization.

(b) The free use of subway rights which the city has had for years and from which it has until now benefited only to a small degree.

(c) Economy in construction and operation resulting from the adoption of all recent improvements and from having in view a single purpose—public lighting—without the complication incident to furnishing a general commercial supply.

On Dec. 24, 1887, Chicago placed in operation its first municipal lighting station, and on Dec. 24 last completed its fifteenth year of municipal ownership and operation of an electric lighting system. For the year 1902 the total cost per lamp of 2,000 c. p. per year is stated by it to be $53.51. The city of Chicago also publishes a report showing all that has been expended for construction and operation of its electric light plant from 1887 to 1902. It has cost that city during 16 years $3,400,663. The total amount rented electric lights would have cost Chicago for the corresponding period is $3,535,876. I do not know that Chicago gives us the most successful example of municipal lighting, but their statement does not involve intricate questions of bookkeeping. It does show that Chicago has earned the cost of its electric plant, which includes the cost of considerable subway construction. The plant at present provides 4,640 arc lamps of 2,000 c. p.

Detroit has also a municipal plant. In a report dated June 30, 1902, the cost of a 2,000-c. p. lamp for Detroit is given at $63.82. That sum includes operating disbursements, interest of 4% on investment, depreciation of 3%, and loss of taxes (that is to say, the taxes that would have been paid on a corresponding plant owned by a private company). The "Electrical World and Engineer" makes a critical analysis of this report in its issue of Feb. 28, and expresses the opinion that 2,000-c. p. lamps cost the city of Detroit $80 instead of $63.50; $80, however, compares very favorably with $146 that we are asked to pay.

I believe that New York with its own plant could provide electric lighting for public uses at a cost much below what is now charged the city. Whether reasonable prices can be obtained from private companies or whether the city can with better results maintain and operate its own plant is for you to determine. I do, however, urge that legislation be immediately asked and that you be given the power to establish and maintain an electric plant for street lighting in case later you decide that it is in the interest of the public so to do. Respectfully,

R. G. Monroe,
Commissioner of Water Supply, Gas and Electricity.

New York, March 12, 1903.

Department of Water Supply, Gas and Electricity,
Commissioner's Office, 13-21 Park Row.

Hon. Robert Grier Monroe, Commissioner of Water Supply, Gas and Electricity, New York.

Sir: In response to your request I would herewith report on the existing condition of the lighting of the City of New York and in regard to the prices charged for same as well as the contracts between the city and the electric and gas companies for the lighting of the said city during the ensuing year. This report applies to the Boroughs of Manhattan and the Bronx, referring slightly to the Boroughs of Richmond, Queens and Brooklyn.

CONDITION OF LIGHTING.—The City of New York outside of the central ridge of the island in the Borough of Manhattan is badly lighted, old style open flame gas burners being used largely on the east and west sides and even in a number of residential districts in the central portion. All these lamps should be changed to mantle burners. The Borough of the Bronx is growing so rapidly that the present systems of lighting are inadequate and the results unsatisfactory, as you can see by the complaints coming into this office continually. The Borough of Richmond is also poorly lighted and should be given considerable attention. Up to date the system of inspection in all of these boroughs has been inadequate on account of lack of men. The present system of repairs to gas lamps is expensive and should be changed, as is shown later.

PRICES PAID.—The Borough of Manhattan pays the following prices for electric lighting:

	Per year.
Open series arc lamps, 2,000 c. p., 425 watts consumption	$146.00
Enclosed arc lamps, direct current, low tension, 2,000 c. p., 425 watts consumption	146.00
Enclosed arc lamps, 2,000 c. p., alternating current, 450 watts consumption	146.00
Enclosed arc lamps, 900 c. p., 230 watts consumption	102.20
Double arc lamps, each 900 c. p.	182.50

The prices are about the same in the Borough of the Bronx and in Richmond, except that they use the 1,200-c. p. lamp in some instances, which is charged as follows:

	Per year.
Enclosed arc lamp, 1,200 c. p., 300 watts consumption	$125.00

This same lamp is charged at $124.50 in Brooklyn and $116.80 in the section of Flatbush.

For gas in New York we pay $17.50 per year per lamp supposedly of 22 c. p., and burned in an open flame burner. This is the price charged by the Consolidated Gas Co. The Standard Gas Light Co., where its mains

extend, charges $13.04½ per lamp per year for presumably 20 c. p. gas. The New Amsterdam Gas Co. charges $12 per lamp per year for presumably 25 c. p. gas, these prices being limited to these amounts by the latter companies' charters. In other parts of Greater New York the candle power varying from 20 to 25 the bids are $16, $22, $24 and $25. For mantle burners in the Borough of Manhattan the Consolidated Gas Co. charges for a single mantle burner $29 per year, nominally 60 c. p.; for a double burner, $47. Other boroughs must pay $30 for these lamps. The price for mantle burners includes all repairs, as well as illuminant. The price for open flame burners includes the lighting, extinguishing, cleaning, reglazing, etc., but the city furnishes a certain amount of material to the Gas Co. for this purpose.

TABLE I.—Prices Paid for Electric Street Lights in Various Cities.

Name of City.	No. of lamps.	Price per yr.
Municipal Plant, 1,200 c. p.:		
Jamestown, N. Y.	338	$48.00
Jacksonville, Fla.	220	54.00
Grand Rapids, Mich.	529	68.54
Municipal plant, 2,000 c. p.:		
Columbus, O.	320	47.00
Chicago, Ill.	4,640	53.51
Detroit, Mich.	2,133	63.82
St. Joseph, Mo.	70	70.12
Allegheny, Pa.	1,414	74.29
Jacksonville, Fla.	151	90.00
Private Plant, 1,200 c. p.:		
Duluth, Wis.	364	55.00
Norfolk, Va.	350	58.00
Covington, Ky.	290	65.00
Portland, Me.	305	66.00
Rochester, N. Y.	450	66.61
Savannah, Ga.	513	72.00
Concord, N. H.	130	75.00
Hartford, Conn.	799	75.00
Springfield, Mass.	900	75.00
Des Moines, Ia.	178	75.00
Gloucester, Mass.	66	82.00
New Haven, Conn.	550	82.12
Bridgeport, Conn.	525	83.00
Chester, Pa.	154	84.00
Lawrence, Mass.	185	85.00
Kingston, N. Y.	131	85.00
Brockton, Mass.	268	87.00
Elizabeth, N. J.	150	92.50
Dallas, Tex.	350	93.95
New Bedford, Mass.	211	98.50
Cambridge, Mass.	533	100.00
Chelsea, Mass.	224	100.00
Yonkers, N. Y.	324	109.50
New York, N. Y.	872	125.00
Private Plant, 2,000 c. p.:		
Evansville, Ind.	300	60.00
Erie, Pa.	449	61.86
Portland, Ore.	712	64.32
Wilmington, Del.	208	64.92
Peoria, Ill.	641	65.00
Saginaw, Mich.	201	65.00
Seattle, Wash.	157	66.00
Dayton, O.	435	68.50
Altoona, Pa.	222	70.00
Oswego, N. Y.	243	71.00
Salt Lake City, Utah	425	72.00
Washington, D. C.	939	72.00
Cincinnati, O.	3,750	72.00
St. Louis, Mo.	2,650	74.55
Superior, Wis.	163	75.00
Davenport, Iowa.	58	75.00
Mobile, Ala.	275	75.00
Johnstown, Pa.	295	75.00
Rochester, N. Y.	2,350	78.47
Lexington, Ky.	306	78.50
Elmira, N. Y.	328	80.00
Knoxville, Tenn.	300	80.00
Birmingham, Ala.	245	80.00
Burlington, Vt.	208	80.00
Los Angeles, Cal.	1,050	81.00
Harrisburg, Pa.	418	80.00
Atlanta, Ga.	819	82.50
Kansas City, Mo.	459	82.50
Cleveland, O.	1,076	82.92
Milwaukee, Wis.	1,812	82.98
Toledo, O.	1,012	83.00
Binghamton, N. Y.	355	83.95
Louisville, Ky.	1,758	84.00
Lancaster, Pa.	312	85.00
Chattanooga, Tenn.	225	85.00
Indianapolis, Ind.	1,500	85.00
Memphis, Tenn.	350	85.00
*Nashville, Tenn.	382	85.00
Syracuse, N. Y.	1,282	85.78
Poughkeepsie, N. Y.	306	89.00
Denver, Colo.	968	90.00
Lawrence, Mass.	169	90.00
Trenton, N. J.	388	92.87
Omaha, Neb.	446	94.50
Des Moines, Ia.	70	94.92
Pittsburg, Pa.	2,530	96.00
Jersey City, N. J.	1,377	97.50
Charleston, S. C.	163	97.50
Newark, N. J.	1,850	98.55
Baltimore, Md.	1,584	99.92
Hoboken, N. J.	246	100.00
Fitchburg, Mass.	304	100.00
New Orleans, La.	1,664	100.00
Paterson, N. J.	741	102.60
Atlantic City, N. J.	376	105.85
Minneapolis, Minn.	203	108.50
Worcester, Mass.	744	109.50
Fall River, Mass.	789	109.50
Utica, N. Y.	693	109.50
Lynn, Mass.	286	109.79
Philadelphia, Pa.	9,426	110.12
Manchester, N. H.	494	115.00
Providence, R. I.	1,870	118.62
San Francisco, Cal.	930	120.00
Camden, N. J.	509	120.50
Albany, N. Y.	671	121.80
Boston, Mass.	3,670	124.10
Haverhill, Mass.	47	125.00
New York, N. Y.	3,876	146.00

*Nashville—Lately changed to municipal plant. Philadelphia—Number of lamps not confirmed. New Orleans—Price changed. Harrisburg—Price changed.

PRICES PAID FOR LIGHTING PUBLIC BUILDINGS.—This department paid for lighting public buildings last year $68,290. Beginning this year this department took over the lighting of a large number of public buildings not previously included, so that this year, as closely as can be approximated, the department will have to pay out from $300,000 to $350,000 for lighting public buildings with incandescent electric lamps and gas lamps. The price paid for this electric current is 10.15 cts. per KW. hour; for gas we are charged in Manhattan at the rate of 90 cts. per 1,000 cu. ft.

COMPARISON AND CHECKING OF DATA.—In order to compare the price that this city pays for electric and gas lighting, returns were procured from 175 cities varying in size from a city of 25,000 people to a city of over 1,600,000. This data was checked, so far as possible, in this way: Letters were written to each of the electric light companies and to each gas company in each city; also to the public officers of the city. The returns of the companies were checked with the returns of the cities, the latter being often in the form of printed reports and these results were checked with the standard electric light and gas directories. In some cases these reports were further checked by personal consultation with city electricians and other engineers. While there may be some slight chance of error in any individual return, I do not believe that the average of these returns is wrong by 1%. The data as received shows the number of lights, candlepower and price paid, the price of coal, the length of term of contracts in years, methods of manufacture and so on. The result of the returns from the first hundred cities answering were then concentrated to show the range of prices and number of lamps, and is herewith submitted on Chart C (Table I.) for electric lighting and on Chart D (Table II.) for gas lighting. We found that neither the cost of coal, number of lights or length of contract had any comparative effect on the prices paid. New York using 4,748 arc lamps pays $125 to $146 each. Evansville, Ind., with 300 pays $60. Wholesale use, while it cheapens the price to the private consumer, is of little benefit to cities. Of the hundred cities we find that eight of them have municipal plants, of which three use 1,200-c. p. lamps and six use 2,000-c. p. lamps. Jacksonville, Fla., is in both classes, using both types of lamps. Ninety-one cities buy light from private companies. Of these 23 use 1,200-c. p. lamps and 68 use 2,000-c. p. lamps.

AVERAGE PRICES, ELECTRIC LAMPS.—The 68 cities using 2,000-c. p. lamps purchasing from private companies pay an average price of $88.60, the lowest being Evansville, Ind., which pays $60, and the highest being Haverhill, Mass., paying $125 per year per light. New York pays $146 per lamp per year for its 2,000-c. p. lamps.

The 23 cities burning 1,200-c. p. lamps pay an average price of $81.08, the lowest being the city of Duluth, which pays $55, and the highest being the city of Yonkers, paying $109.50 per lamp per year. The bid to the city of New York this year for equivalent lights is $125 per lamp per year.

The six cities operating their own municipal plants burning 2,000-c. p. lamps pay an average price of $66.45 per lamp per year, the lowest being paid by the city of Columbus, O., $47 per lamp per year, and the highest Jacksonville, Fla., $90. It must be remarked, however, that Jacksonville, Fla., sells its lights to the city at a profit and at the end of the year pays back to the city the amount over its operating expenses. The city of New York pays $146 per lamp per year for the same service.

The three cities using 1,200-c. p. lamps, and having their own municipal plants, pay an average of $56.84 per lamp per year, the lowest being Jamestown, N. Y., $48, and the highest the city of Grand Rapids, Mich., paying $68.54. The city of New York pays $125 per lamp per year for the same service.

AVERAGE PRICES IN LIGHTING PUBLIC BUILDINGS.—The 100 cities gave us general returns as well for the cost of lighting public buildings. We find the average price for electric current per kilowatt hour is 10.6 cts.; for gas per 1,000 cu. ft., the cost is $1.10. In municipal plants these lights are often given to the city free and included in the cost of arc lighting, but in other instances cost the city about an average of 3 cts. per KW. hour for electric light.

AVERAGE PRICES, GAS LAMPS.—Chart D (Table II.) showing gas statistics is in two sections, the one at the left (upper) showing the price of open-flame gas burners and the number of burners used. New York is well up on this list, it paying for the greater bulk—14,460—of its open gas lamps $17.50 for gas and maintenance plus 60 cts. each for repairs, this being the average cost of repairs for the last five years. The city paying the lowest price is Wilmington, Del., which pays $13.80 per lamp per year, and the highest being New Haven, Conn., which pays $22. The average of these prices for ten cities is $19.52 per lamp per year, including repairs. The city of New York pays $18.19 for the same service. The section on the right (below) shows the price and number of lamps with mantle burners. New York is next to the top of this list at $29 and in some boroughs pays $30. The lowest in cost of these cities is the city of Chicago, which pays $18.55, this being secured by purchasing its gas and making its own repairs and maintenance; the highest price—$31—being paid by the city of Binghamton, N. Y. The average of these prices for 22 cities is $27.20 per lamp per year. All averages in gas and electric figures exclude New York.

All the cities given above purchase their gas from private companies, the saving lying mainly in repairs and maintenance. You will note that if we had the New Amsterdam prices all over the city we could equal Chicago by maintaining our own gas plants, but on the New Amsterdam lines we only have 2,981 lamps.

UNDERGROUND CONDUITS.—It is often stated that the high price paid by the city of New York for electric lighting is due largely to the charge for underground conduits, but in the borough of The Bronx, where there are but few underground conduits, the New York Edison Co., the Bronx Gas & Electric Co., and the Westchester Lighting Co. all charge $146 per year for 2,000-c. p. lamps, the same as in the borough of Manhattan where there are underground wires. In looking up this matter we meet a curious condition of affairs. In 1901 the city of Chicago in its report stated that it cost $219 per arc lamp for subway transmission. In 1902 it revised this figure and said that the cost was about $175. The city of Detroit built its conduits for $1,716 for a mile of single duct 3½ ins. in diameter. It rents to any customer a single duct on its underground system for $264 per mile per year, with a discount of from 10 to 20% if more ducts are taken. The city of Cincinnati paid $12 per lamp per year more for underground lights than for overhead lights, and it will be noticed that this is 6% interest on a $200 cost of construction. Milwaukee allows $18 per year for the same thing. This is 6% on a $300 cost of construction.

In view of the prices given above the statement that the New York Edison Co., which is one of the Consolidated Cos., pays the Subway Co., another of the Consolidated Cos., $900 per mile per year for a 3-in. duct, seems to be very extraordinary, and it looks as though a large profit were paid from one pocket to the other pocket of the same concern, which gives, if not analyzed, an apparent reason why the lighting company should receive a higher price for lighting the city because it has to pay a high price to the Subway Co., each company working for the same interest. Ordinarily it would seem proper to allow a difference between underground and overhead lights, but this city can compel the Subway Co. to give them free conduits, and if they haven't enough room to accommodate the present or future requirements, the city can compel them to build same free of cost. In these figures, therefore, no allowance is made.

PRESENT BIDDERS FOR LIGHTING.—With reference to the bidders for the lighting business of the city of New York the history of the different companies shows a series of consolidations which created a community of interest in all the boroughs of the city, particularly so in the boroughs of Manhattan and The Bronx. Any bids we may receive will undoubtedly come from the same source and will represent this community of interest by a division of territory or by a scaling of bids. This information can be readily obtained by reference to the various gas and electric light directories, Manual of Statistics, and records of the various investigations by commissions so far conducted in the affairs of lighting this city.

RESUME OF EXISTING CONDITIONS.—A resume of the above facts shows:

(1) That this city is a very large consumer of electric

TABLE II.—Prices Paid for Gas Street Lights in Various Cities.

Name of City.	No. of burners.	Price per yr.
Welsbach Burners.		
Chicago, Ill.	11,025	18.55
Baltimore, Md.	6,174	21.40
Dayton, O.	700	22.50
Portland, Me.	329	23.00
Charleston, S. C.	400	23.50
Seattle, Wash.	5	24.00
Cleveland, O.	5,452	24.56
Wilmington, Del.	518	25.75
Milwaukee, Wis.	2,500	28.00
San Francisco, Cal.	5,079	28.60
New Bedford, Mass.	713	28.75
Rochester, N. Y.	143	29.00
Cambridge, Mass.	284	29.88
Boston, Mass.	9,119	30.00
New Haven, Conn.	1,000	30.00
Yonkers, N. Y.	1,624	30.00
Lancaster, Pa.	270	30.00
Jersey City, N. J.	460	30.00
Providence, R. I.	793	30.00
Omaha, Neb.	1,050	30.00
Worcester, Mass.	500	30.00
Binghampton, N. Y.	176	31.00
New York, N. Y., Manhattan	4,138	29.00
New York, other Boroughs	3,956	30.00
Open Flame Burners.		
Wilmington, Del.	31	13.80
Chicago, Ill.	13,852	16.15
Cincinnati, O.	2,500	16.75
Hoboken, N. J.	71	17.50
Paterson, N. J.	450	18.00
Washington, D. C.	6,989	20.00
Nashville, Tenn.	525	20.00
Camden, N. J.	289	21.00
New Haven, Conn.	37	22.06
New York, N. Y., Manhattan	2,981	12.00
" " "	1,585	13.04
" " "	8,854	17.50
" " Bronx	2,020	22.00
" " Bronx	3,586	24.00
" " Brooklyn	6,383	16.00
" " Brooklyn	4,266	28.00
" " Queens	469	22.00
" " Queens	2,742	25.00

current for electric lighting of all kinds and of gas for gas lighting.

(2) That the price it pays is very high and at these prices sufficient money can hardly be allotted to this department to keep pace with the growth of the city.

(3) That it pays higher prices apparently for electric arc lighting than any other city in this country, under equivalent circumstances. That it pays a high price for gas, for maintenance service from gas companies, and almost the highest price for mantle lighting.

(4) It has no possible source of relief through competition now, nor can it expect to get any relief from future competition except of the most temporary character. In some way, however, it must meet the demands of its citizens and at the same time protect itself from such flagrant overcharges as have been shown.

RELIEF POSSIBLE.—There seem to be only two possible sources of relief. The first is such publicity and agitation as will force a reduction in prices by the present bidders. This is improbable and might be only temporary, although the increased business to the producers of electric current and gas would very soon make up for the decreased price per light.

A second method of relief is that this city take the advantage taken in a number of instances by other cities similarly situated and build and operate its own plant. This is what is known as municipal ownership. We do not pretend to regard municipal ownership as a cure-all under all circumstances, but as is shown further on, this city is in such a position that it can build a plant cheaply on account of free conduits and even if it operates it expensively the price per light will still be far below the prices it pays at present. In endeavoring to show this, details are given of the status of affairs in Chicago, Detroit, Allegheny and Jacksonville, Fla., which are the most noticeable of the eight cities reported to us.

RESULTS OF MUNICIPAL OWNERSHIP.—The city of Chicago states in its last report, the advance sheets of which you have, that it costs $53.51 to produce a 2,000-c. p. arc light running all night and every night, and in this charge it includes all that it deems necessary in the way of new material and repairs to keep its plant to date. It does not, therefore, charge depreciation, for its theory, if carried far enough, will cover depreciation. In the last 16 years of operation it has expended the sum of $3,400,663 for lighting the city and for building its own plant, whereas if it had purchased from private companies during that period at prevailing prices it would have cost $3,535,876, and it would not have a plant. It has issued no bonds and it owes nothing on its plant, which cost to date $1,684,000. Whether Chicago states the price of lighting properly or not could hardly be taken as an argument against the conditions confronting this city. If it doubled its price it would still be nearly $40 per lamp below New York. No matter what method of bookkeeping is applied to it, it owns to-day its own plant, which is operating satisfactorily, and, so far as is known, is furnishing satisfactory light. In addition to the cost of its plant Chicago has also built and maintains quite an amount of underground conduits. This expense we would not have. As you have noted Chicago operates 4,640 arc lamps. It would be apparently safe to assume then that New York could build a plant for at least the price Chicago built hers, which would furnish the present number of arc lamps—4,748. If New York could produce light as cheaply as Chicago it could build its own plant out of the price it now pays. This is just what Chicago did. It paid for its plant from what it would have paid other companies to light the city besides doing its own lighting.

DETROIT, MICH.—In Detroit, when its plant was built, it issued $650,000 in bonds and they have spent since then, including some replacements, renewals and considerable subway construction, $932,000. The difference between the bond issue and the total investment is taken care of by direct taxation, the bond issue is taken care of from the general sinking fund, so that Detroit does not make quite as favorable a showing as Chicago, but in ten years of its existence before building the municipal plant, from 1885 to 1894, inclusive, Detroit paid an average price per lamp of $177.27, with an average number of lamps of 803. The lowest price during this period was $128.87, in 1893, in which year it used 1,279 lamps. It paid for the year ending June 30, 1902, according to its own statements, $63.82 for a 2,000-c. p. lamp burning all night and every night. In other words, it is now furnishing 2,035 lamps at a total cost of $129,874, where previously it was getting an average of 803 lamps for a total price of $142,347. When this is taken into consideration it would show that Detroit has paid to date to the city a considerable sum of money to apply on the cost of its plant. The statement that Detroit produces a light for $63.82 per year is strongly criticised, particularly in the "Electrical World and Engineer" of Feb. 28, 1903. This paper states that the lights cost Detroit $80 per year, the principal difference being on the question of the proper rate to charge for depreciation. Let us suppose the "Electrical World" is entirely correct. The city of New York pays $146, and if it could get a light for $80 per year it would save very large sums of money. Detroit furnishes its public buildings with light at a cost of 3.7 cts. per KW. hr. Chicago practically furnishes some of its public buildings with light free.

ALLEGHENY, PA.—Allegheny has a municipal plant which furnishes 1,414 2,000-c. p. arc lamps at the rate of $74.29 per lamp per year. It furnishes its public buildings with light at 2.74 cts. per KW. hr. It issued $260,000 in bonds to build its plant, but has since paid into a sinking fund to retire these bonds over $82,000. The information is not given as to what the price was that Allegheny had to pay before it built its municipal plant, but if this were taken into consideration, as in the case of Detroit, we have no doubt it would show approximately the same result, for the city of Pittsburg, immediately across the river from Allegheny, pays $96 per year for its arc lamps.

JACKSONVILLE, FLA.—The city of Jacksonville has a method of operating and financing which differs from the others materially. It operates its plant as an electric light company would, and it charges the city for arc lighting and for lighting its public buildings, profitable prices. It also supplies private consumers and charges them profitable prices. At the end of the year, after taking out their reserve fund, interest and other proper charges, it pays the balance of its profits back into the treasury of the city to apply on taxes. Last year it paid the city about $22,000. It charged the city $90 a year for a 2,000-c. p. arc lamp and it charged public buildings 7 cts. per KW. hr. You will see, therefore, that these prices on the chart should be corrected as they include profit. The other municipal towns charge what they deem actual cost.

COST OF MUNICIPAL PLANTS.—In order to show the cost of building these plants I would submit the following table:

Name of City.	Cost of plant.	No. of lights operated.	Cost to build per light operated.
Jamestown, N. Y.	$95,000.00	338	$281.00
[1]Jacksonville, Fla.	228,723.79	371	616.50
Grand Rapids, Mich.	194,721.65	529	368.00
Columbus, O.	Not given	320	.....
[2]Chicago, Ill.	1,684,000.00	4,640	363.00
[3]Detroit, Mich.	932,232.20	2,133	437.00
St. Joseph, Mo.	103,000.00	421	244.00
Allegheny, Pa.	327,944.43	1,414	232.00

[1]This includes cost of commercial lighting plant as well. [2]Includes subway construction. [3]Includes subway construction and incandescent plant.

ARGUMENTS AGAINST MUNICIPAL OWNERSHIP.—Refering to some of the arguments against municipal plants, it is a curious fact that the interest account, depreciation account and taxes are among the items particularly attacked by those in favor of private ownership. It will be noted that the accounts of municipal plants are open to examination and criticism of all kinds, but we have yet to see outside of the state of Massachusetts a full statement of the amounts charged up for depreciation, including replacements and renewals, interest and taxes from the general run of electric light and gas companies in the United States. Until their books are subject to the same criticism as those of a plant owned and operated by a municipality, we have not a fair comparison between the two systems; for instance, when the various companies in this city consolidated and a number of plants were abandoned, so far as we can find out no depreciation charge was made for this. On the contrary, the stock was increased. It is also stated that we may change our method of producing electric light requiring entirely new machinery on a new system, although the present electrical machinery operates in units of reasonable size at over 90% efficiency. If this is true, does it not equally apply to all private companies? Corruption is charged on all sides as the first result of municipal ownership. A municipal plant of any size now operating in the United States will have to meet every year the published reports of plants doing as well as Chicago, Detroit, Allegheny and Jacksonville. This, if followed carefully by the public press, will certainly govern any municipal plant to a marked extent. One of the principal arguments brought up against municipal ownership is that the city of Philadelphia had a gas plant which was given up as a failure and is now operated by a private company. Apparently no one has ever cared to state the real reason why it was given up and we do not suppose any one ever will. Without the reasons why, the failure of Philadelphia teaches no lesson. The city of Boston is often quoted as having made a most careful examination of municipal ownership within the last few years and finally decided to buy their lights from a company; the reason is plain. The company made a contract with Boston which carries with it all the advantages of municpal ownership. In brief, after a period of two years and six months after signature, Boston had a right to establish exactly what it cost the electric light company to produce public lights, and the company was bound to aid them in every way to do this. They were then to add 7% for depreciation and 6% for interest on the cost of the plant used for public lighting. For a period of five years, the resultant prices per arc lamp was to govern. If it did not the city could make a claim that it would only pay what lighting would cost when produced by such new system. If the city of New York had a contract of this kind it is all we could ask. It is the essence of municipal ownership, as it makes the company practically the agent of the city.

NEW YORK'S STANDPOINT.—From the standpoint of New York, from the data given of municipal plants above, as well as from other reports which have come in too late to be charted, the fact remains that these municipal plants under similar circumstances have saved their respective cities large sums of money, represented either in plants or decreased cost of lighting, and that even were their prices raised in reason this city could at the raised prices either save a large amount of money every year or devote the saving to lighting and thereby light the city properly.

ESTIMATED SAVING OF MUNICIPAL OWNERSHIP.—The following statement shows approximate savings:

New York now uses:		
3,876 2,000-c. p. arc lamps at $146 per yr.	$565,896	
872 900-1,200-c. p. at from $102.20 to $182.50 per year	120,480	
Present cost		$686,376
At average prices of other plants:		
$88.60 for 2,000 c. p. } $81.08 for 1,200 c. p. { would cost		414,116
Saving at these prices per year		$272,261
Present cost brought down	$686,376	
At municipal plant prices:		
3,876 2,000 c. p. at $66.45 } 872 900-1,200 c. p. at $56.84 { cost	$307,124	
Saving per year		$379,252
Public building lighting now costs:		
Approximated for 1903, at 10.15 cts. per KW. hour	$383,317	
On a basis of 3 cts. per KW. hr., as shown by municipal plants, would cost	113,324	
Saving at this per year would be		$269,938
We pay now for open-flame gas burners and mantle gas burners per year	505,420	
If we change from open-flame lamps to mantles and operate on the same basis as the city of Chicago, it would cost	464,036	
Saving over our present cost		$41,384
A total saving on a municipal basis of		$690,574
And if instead of operating on a municipal basis for arc lamps we operate at the average price of other cities with public buildings on present rates the saving would be		$293,833

In deriving the saving in gas lamps we arrived at it in this manner: In changing the open-flame gas lamps to mantle lamps we would possibly save 10% in number. We now have 21,187 open-flame lamps; 10% from this leaves 19,069, which we would have on a mantle basis. We have now 6,581 mantle lamps, making a total of 24,650. We pay for these at present from $20 to $30, depending on the locality; say, $29. The cost then per year for all mantle lamps at present prices would be $726,323 per year. Taking the same number of lamps at Chicago prices, which is $18.55 per mantle lamp per annum, the result in cost would be $464,036, a saving of $262,287 per annum over present prices. But we do not use all mantle lamps now. We pay for open-flame lamps $332,098 per year; for mantle lamps, $173,322 per year, a total of $505,420. If we change to all mantle lamps and obtain Chicago's prices it would cost us $464,036, a saving over present conditions and prices of $41,384 per annum. Chicago's prices are derived as follows: They buy their gas from the gas company for $12 per annum; they pay $3.67 for lighting, cleaning and extinguishing. They pay 50 cts. per annum for repairs, and they pay $2.40 per annum for repairs due to mantle lighting, a total of $18.55.

CONCLUSIONS.—From the above statements it appears the conclusions to be drawn are: (1) New York should receive much lower prices than it does. (2) That it would be very profitable for it to operate its own electric plant, one capable of furnishing all its arc lights and all incandescent lights necessary for public lighting. (3) To reduce its number of gas lamps by increasing electric arcs at the lower prices obtained; change all its open-flame lamps to mantle burners and maintain them itself or through contracts with private parties for repairs, etc. (4) It would also seem advisable that its present bids for lighting for the year be rejected and new bids taken under revised contracts, which will give it at least a chance to save in mantle gas lights, this having been demonstrated as possible under existing circumstances. In electric lighting it should be given more authority to enforce penalties for outages or other neglect. All of which is respectfully submitted.

C. F. Lacombe, Engineer of Surface Construction, Department of Water Supply, Gas and Electricity.

New York, March 9, 1903.

A NOVEL GRAVITY TRAMWAY is operated at a slate quarry near Placerville, California, where it is necessary to raise the slate several hundred feet up the side of a mountain. To do this an ordinary gravity incline has been built, and an iron barrel is mounted on a car. This barrel is filled with water at the top of the incline and its weight as it descends pulls the loaded car of slate up. The barrel is provided with a valve that automatically discharges the water at the foot of the incline. The empty slate car, being heavier than the empty barrel car, pulls the latter back up. We take the above from a description in "The Mining and Scientific Press," and may add that time would be saved were there a water barrel on each of the two tram cars, with space also provided on each for the slate.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter. Published every Thursday at St. Paul Building, 220 Broadway, New York, by THE ENGINEERING NEWS PUBLISHING COMPANY

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ALFRED E. KORNFELD, New York, M. C. ROBBINS, Chicago, J. B. READ, Boston, ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE., 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 10 weeks, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $8.00; Thin Paper Edition, One Year, $5.75. SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 means that subscription is paid to the 32d week (that is the issue of Aug. 6) of the year 1903; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The gas and electric lighting interests of New York city having been allowed all the rope they would take, they have certainly well-nigh hung themselves, as may be seen by reading the two reports on public lighting in Greater New York, printed elsewhere in this issue. To write more directly to the point, under the shadow of alleged competition in the interests of the public the gas and electric lighting companies of New York have been allowed to duplicate stations and parallel mains until they have rolled up a capital expenditure many times in excess of what was needed to supply equally good lighting facilities, and then, when the inevitable consolidations have come, they have been allowed, again and again, to multiply their already excessive capitalization. In those outlying districts where so-called independent companies exist, the territory has been divided so as to prevent competition, and throughout the whole city, in years past, there has been another sort of "community of interest," namely, between private corporations and political powers. These conditions, combined with one-year contracts, have enabled the lighting companies to fix their own prices for public lighting, and have also given them a free hand, so far as municipal control is concerned, in their private service. But the very lengths to which the lighting companies have gone now threaten to be their undoing, for their recent high bids, and division of territory where competition exists in theory, have led the city officials to make a quiet investigation of public lighting in New York and elsewhere. The results of this investigation show that the only safety for New York lies in securing legislative power to establish a municipal plant for lighting streets and public buildings. Combined with this it is proposed to obtain authority to make a ten-year contract for public lighting, possibly with a provision for adjustment of prices every 2½ years. An alternative like this seems to be absolutely necessary if the city is ever to regain the control of the lighting situation which it has so completely and so impotently surrendered. But should not the city also improve the opportunity now afforded to safeguard private consumers as well as the public treasury? Public and private lighting go naturally together; and certainly if there is any likelihood that both are to remain in the hands of companies the city should take steps to control prices and quality of service of one as well as of the other. This does not mean that the city must of necessity establish a plant of its own for either public or private service, but it ought to be in a position to do either or both in case the private companies are unwilling to reduce their rates for street and house lighting to such a basis as will yield only a reasonable profit, and at the same time to submit to such public regulation as will ensure good service and justice to all. If the companies could be guaranteed fair treatment in the future, and a proper contract for a term of five or ten years, doubtless they would quickly make valuable concessions to the city and to consumers. Anyhow, it is only fair to assume their willingness to adopt the same principles regarding reasonable rates, control by the public, and publicity of accounts, as have been announced by other members of the gas and electric lighting fraternities within the past two or three years. Finally, we challenge anyone to show so heavy a capitalization for services rendered in any city under municipal ownership as is found in New York under private ownership of these public utilities.

A practical example of co-operation between engineering societies, or rather of co-operation between the members of different engineering societies, is reported from Schenectady. According to the Schenectady "Gazette," a movement is under way to establish a local engineers' organization made up of members of the four principal national engineering societies—the Civil, Mechanical, Mining and Electrical engineers. The Institute of Electrical Engineers has already a local chapter here with about 70 members, and it is proposed to make this a general local engineering society, including in its membership resident members of the other national engineering societies, as well as other engineers in this vicinity.

It seems to us that this movement should be an object lesson to the national engineering societies as to the lines on which their proposed establishment of local chapters must be conducted, if it is to be successful. The Electrical Engineers have done more experimenting in this direction than any other of the national societies, and with isolated exceptions their local meetings have been successful only when held in connection with some other organization. The Mechanical Engineers are discussing some move of the same sort, and the subject is likely to come up for action at the annual meeting in May.

It is to be hoped that such action may be taken with a clear understanding of the situation and of the necessity for co-operation if any useful result is to be attained.

Many of our readers know something of the difficulties at present found in maintaining local engineering societies in the smaller cities. Suppose, in one of these cities, say Pittsburg for example, it were proposed to maintain in addition to the existing local engineering society (the Engineers' Society of Western Pennsylvania), local chapters of the Civil, Mechanical, Mining and Electrical Engineers——five societies in all—each with its separate meeting rooms, officers, and other paraphernalia. The impracticability of such a scheme is patent on its face.

On the other hand, the resident members of the national engineering societies ought to and do find a prominent place in the local engineering society. Co-operation to that extent is already a reality. As to how this co-operation may be extended, the most fruitful suggestion we can make is that the papers read before the national engineering societies might be taken up for discussion in the local engineers' clubs. The lack of good papers is now the weak point of these local engineering societies, for a man with a really valuable and important paper to present, prefers to give it to one of the national societies, where it will reach a much larger number, attract wider attention and be permanently preserved; or else he sends it to an engineering journal which pays cash for contributions.

On the other hand, it would be a great advantage to the national societies to have their papers discussed in the local clubs; and they could well afford to spend a considerable sum in furnishing extra copies of their papers to these local societies in order to bring this about. The weak point of the national societies is that a paper read before them often receives inadequate discussion—not enough to either bring out its strong points or expose its errors. This is particularly true of the Mechanical and Mining Engineers' Societies.

Nothing is more disappointing to the author of an elaborate paper than to present it before a society of his professional brethren and have it received in cold silence, with no one to offer a word of comment in either praise or blame. From this point of view the national societies would be by far the largest gainers in co-operating with the existing local engineers' clubs.

Is there any paving material for teamways in ferry boats, freight houses, pier sheds and other places where heavy loads must be moved and where good foothold for horses is a requisite, that is superior on the whole to ordinary wooden plank? This question was submitted to us several months ago by the officers of a company operating a line of ferry boats in New York harbor. They also informed us that they were experimenting with various forms of pavement in the hope of obtaining something better than the old wood planks.

The objections to wood planking are pretty well known. It wears very rapidly and almost as soon as laid it presents a rough, splintery surface, difficult to keep clean. It absorbs and holds water and urine and gives rise to foul odors which are particularly objectionable inside a building. It requires constant expense for repairs and the wear is so uneven, being concentrated in the line where the wheels and wagons pass, that much material is of necessity wasted in renewals.

Nevertheless, the company referred to, after trying brick, asphalt, and Belgian block pavements and also a patented cork composition, have settled on creosoted 1-in. spruce planking as the cheapest wearing floor for ferry boat gangways. The asphalt suffered from the heat and gave trouble both by crumbling and from the wheels of heavy wagons sinking into it, while standing on it. Besides this it was very slippery. Brick was also slippery and crumbled more or less under heavy trucks. Belgian block paving wore well, but was objectionably heavy and extremely noisy. The patented cork block gave excellent results, but was so much more expensive than the spruce planking that the latter was finally adopted.

The only material we can suggest which might possibly have given better results is wood block paving. While doubtless more expensive to lay in the first place, the fact that the blocks worn in the wheelways and hoof ways can be renewed without disturbing the rest should make it much cheaper to maintain. Besides this the blocks can be selected so as to exclude softer parts of the tree and parts showing incipient defects, and much better wear can thus be secured than from the boards or planks of the same wood sawed direct from the log. Furthermore, the pressure in wooden paving blocks comes upon the ends of the fibers, and it is well known that wood wears much better thus than it does when the pressure acts transversely as it does on plank paving.

THE CANAL DISCUSSION IN NEW YORK.

In the New York legislature, during the coming week, a trial of strength is likely to take place between the friends of the 1,000-ton barge canal project and those who prefer the Federal deep waterway. The Finance Committee of the Senate has favorably reported Senator Merton E. Lewis's resolution calling for the appointment of a commission to confer with the United States Government, and see what arrangements can be

made for a Federal deep waterway, to be built either by the United States or jointly by the United States and the state of New York.

The Canal Committee of the Senate, on the other hand, has favorably reported the barge canal bill, which now provides for the issuance of state bonds to the amount of $101,000,000, to be expended in enlarging the Erie, Oswego and Champlain canals to a depth of 12 ft. Payments of the interest on the bonds and to a sinking fund by which the bonds themselves will be paid are provided for in the bill by a tax assessment of .012 mill per dollar of valuation for each million dollars of bonds issued, or a total annual tax rate of 1.212 mills on the dollar for the entire $101,000,000 provided for. The dual control of the work by the State Engineer and the Superintendent of Public Works, which was criticised by Mr. Himes in our issue of Dec. 25 last, is continued. It is provided, however, that all measurements, inspections and estimates shall be made by the State Engineer's force. A special advisory board of "five expert civil engineers" is also provided, but their powers are only advisory.

The whole act is to take effect only on condition that it shall be approved by a majority vote at the state election to be held in November next.

At the assembling of the legislature, the passage of the barge canal bill was generally considered by the press of the state as a foregone conclusion. The discussion which has gone on during the last few weeks, however, has shown a surprisingly large opposition to the barge canal project and a very strong element in favor of Federal action on the deep waterway enterprise, both in the legislature and generally throughout the state. Even in New York city, itself, which has been, with the exception of Buffalo, the chief supporter of the barge canal project, a meeting of prominent financiers and business men was held on March 13, for the purpose of presenting a memorial to Senator Lewis, approving the resolution favoring the Federal deep waterway, offered by him as noted above.

The article in our issue of Feb. 26, comparing the Federal deep waterway and the barge canal has been extensively quoted and favorably commented upon by newspapers in all parts of the state. It has also, as was to be expected, drawn out a chorus of criticisms from the barge canal defenders. With some of these criticisms which deal with engineering matters, it has seemed worth while to deal in this place.

Mr. Gustav Schwab, of the North German Lloyd Steamship Co., in the "New York Tribune" of March 2, reviews our article and claims that the 21-ft. waterway if built "would not fulfil its purpose" because a lake vessel could not transfer its cargo of grain directly into an ocean steamer, at New York, "as she could not go alongside the ocean steamer owing to the conditions in this harbor and for other reasons." The same argument was presented in more detail by Major T. W. Symons, in discussing Mr. Geo. Y. Wisner's paper on "Canals from the Lakes to New York," read before the American Society of Civil Engineers Nov. 7, 1900.

Undoubtedly at the present time ocean vessels are loaded at New York from floating lighters and other craft very much smaller in size than the steamers on the Great Lakes. It does not follow, however, that this is the only possible method of conducting the business. If Lake vessels could steam through a deep waterway to the port of New York there is every reason to believe that modern engineering talent would be entirely competent to provide plant for direct transfer from lake to ocean vessels and vice-versa. If existing vessels using existing docks like the North German Lloyd, found it more advantageous to load from barges, and if all that is claimed for the economy of barge transportation is true, then barges of 1,000-ton or of any other desired capacity could come from the Lakes to New York in a Federal deep waterway just as well and a good deal better than they could come in the proposed 12-ft. deep barge canal.

But suppose there should be exorbitant charges for transfer to these barges at Buffalo or transfer from them at New York, or that the transportation rates of the North German Lloyd itself (which is part of the international steamship trust) should be excessive. If the deep waterway were in existence, any such increase in the cost of shipments or transfers would stimulate competing lines and methods of transfer. We should have the Lake steamships unloading direct into the hold of ocean tramp steamers, carrying cargo not as berth freights, but in entire bulk. If New York transfer charges were too high, we should have the Lake steamers built to cross the ocean, and ocean steamers ascending the canal to discharge their cargoes at Lake ports.

It is because the deep waterway would open a far wider field of competition than the barge canal that it is far more deserving of public support. This idea was expressed as follows in the memorial to Senator Lewis noted above:

> It has been well said that the Erie Canal at the present time is corked at both ends; first, by those who control the facilities for transferring cargoes in the harbor of Buffalo, and second, by those who control the same facilities in the harbor of New York. Is it not high time that these corks should be removed and removed forever?

It seems to be pretty clearly established that among the principal promoters of the barge canal bill are men who are interested in the above-mentioned "corks" and in the perpetuation of "corkage" charges.

There is another point which deserves attention with reference to the argument of Mr. Schwab noted above, and that is that the great bulk of the traffic from the Lakes eastward is not for export, but for domestic consumption. The barge canal advocates seem to have no larger conception of their waterway than as a means of bringing grain in bulk from Buffalo elevators to ocean steamships lying at New York piers. Their great argument for the canal is to save New York's export trade.

This appears to us a very narrow view to take of the matter. The fact is that domestic commerce is of far greater bulk than foreign commerce, and reduction of the charges upon it is of far greater moment to the public. As has been well said by Mr. Geo. Y. Wisner:

> Since at least three-fourths of the freight carried on the Lakes is for domestic consumption and because domestic traffic must increase much more rapidly than that with foreign ports, it seems evident that if any waterway be constructed it should be the one best adapted for the distribution of products and manufactures for domestic use.

To sum up: Mr. Schwab argues that the barge canal is as good as the deep waterway because the barges are just what he needs to go alongside his ships at New York. Our position is that a deep waterway can do everything that the barge canal can do, and many very important things that it cannot.

Another argument brought forward by the barge canal advocates is that barges built to run exclusively on a canal can carry freight at less cost because they cost so much less to build than Lake steamers. The figures given by Major Symons in the New York canal committee's report of 1899 are quoted to the effect that Lake steamers cost $36 per ton of carrying capacity, while canal barges cost only $8. We are told that the entire estimated cost of carrying grain from Buffalo to New York by the barge canal is only 26 cts. per ton, or 0.8 ct. per bushel; and we are asked how it is possible that the additional cost of a deep waterway would be justified if the barge canal can carry traffic at such low rates.

The best answer which we can make to this is to quote figures from the report of this same committee on canals. Turning to page 36 of that report we find it there stated that the total cost of handling grain at Buffalo and at New York is 2.1 cts. per bushel, or 78 cts. per ton, of which 0.775 ct. per bushel is the elevator charge and cost of canal boat trimming at Buffalo. The committee says with truth that "the cost of rehandling is out of all proportion to the cost of transportation;" yet the barge canal which it recommended makes this rehandling a permanent necessity. In this matter, too, we shall err if we consider the canal merely as a transportation route for export grain, or for low-grade bulk freights in bulk alone. As we pointed out in our issue of Feb. 26, by the deep waterway a Lake steamer could sail direct from New York city or Boston or Philadelphia with a cargo of manufactured goods and land them at upper Lake ports without breaking bulk. She could make the return voyage with a load of flour or refrigerated beef, or copper ingots, or lumber, or any of the products of the farms and forests and mines of the Northwest, and could land them at the wharves of any of the Atlantic seaboard cities. The cost of transhipment of goods like these is far in excess of the cost of handling grain and ore and coal; and this cost is likely to increase rather than diminish with the growing power of the labor unions to dictate wages and conditions of labor. Are not facts like these worth the serious consideration of the barge canal advocates? Is it fair to emphasize the estimate of 26 cts. per ton as the cost of the transportation over it and omit mention of the cost of the necessary transfers at each end?

The advocates of the barge canal are very sure that Lake steamers could not profitably come to tidewater through a deep waterway; but stubborn facts show the falsity of their theory. Even as we write, a dispatch from Duluth, published in The New York "Times" of March 17, reports that ten steel steamers are to be completed this spring by the Great Lakes & St. Lawrence Transportation Co. to carry cargo from the upper Lake ports to Montreal and Quebec through the St. Lawrence canals without breaking bulk. The vessels can carry 2,200 tons on the 14-ft. draft permitted by the Welland and St. Lawrence canals.

Doubtless the barge canal advocates will construe this as an argument for their scheme; but to the unprejudiced mind it seems pretty good evidence that the transfer from Lake vessel to canal boat would be fatal to the barge canal's success.

The late Elnathan Sweet, the real originator of the project for enlarging the Erie canal, and President of the Board of Advisory Engineers for the barge canal survey, put the case in a nutshell when he said:*

> No waterway built to connect these waters [the Great Lakes and the Ocean] can hope to secure great commercial importance unless it can accommodate the largest vessels navigating the Great Lakes. . . . . The expenditure of great sums of money for so-called improvements of the present canal is to be discouraged as wasteful, and because it tends to postpone the wise and statesmanlike undertaking of a deep-water outlet for Lake commerce.

LETTERS TO THE EDITOR.

The Brooklyn Dry Dock Contract Decision—A Correction.

Sir: In your March 12 number you have inadvertently misstated the facts in relation to the suit of the U. S. Government against us, recently decided in our favor by a jury in the U. S. Circuit Court for this district. It was *not* found "that many of the piles driven were not the full length called for in the original contract although samples of the short piles removed from the defective part of the dock were brought into court as evidence."

It *was* found that the short piles introduced as evidence were used for temporary work only and that none of the piles used for the permanent work were shorter than the required length.

This makes a great deal of difference in the presentation of the facts, which the jury determined within fifteen minutes after the question was submitted to it.

We trust that you will publish this explanation in justice to our reputation. Very truly yours,

T. & A. Walsh.

96 and 98 Water St., New York City, March 16, 1903.

A Problem in Bridge Design.

Sir: Will you kindly give some of the wise ones an opportunity, through your paper, to explain methods of finding reactions and position of loads for maximum stresses in a structure of general type shown by enclosed sketch.

You will notice that it consists of two cantilever arms meeting at a hinge joint in the center, thus combining the cantilever and three-hinged arch. Any discussions as to adaptability and relative economy of this type for railroad purposes will be duly appreciated.

Yours truly, Subscriber.

Houghton, Mich., Feb. 9, 1903.

(The structure shown is, evidently, statically indeterminate in the second degree. To find the re-

*Transactions American Society of Civil Engineers, Vol. XLV., p. 283.

actions under a given loading, the method of deflections should not prove difficult of application. What is the best way to do this, and what are the simplest general formulas, is offered to our readers as an interesting problem. The second inquiry in the above letter is a harder one: what is the easiest way to find the position of maximum loading. To draw the influence line for each member suggests itself as perfectly satisfactory, but possibly someone of our readers may be able to offer a better method. In connection with the discussion of the preceding questions it is appropriate to consider how to proceed for approximate design, i. e., how can the sizes of the members be approximated for the purpose of the exact investigation of reactions. The methods available for the approximate design of two-hinged and fixed-end arches would appear to be hardly satisfactory for use in the present case. As to the utility of this type of arch-frame, we think that if a longitudinal sliding joint were substituted for the pin joint at the center, the structure would be much better suited to practical use; it would then be only singly statically indeterminate, calculation would be greatly simplified, and temperature stresses would be avoided.—Ed.)

The Attitude of Workmen Toward the Bonus System.

Sir: The article on "Gift Propositions for Paying Workmen," in your issue of Feb. 19, is of interest to all employers of labor. The experience of this company during the past year has revealed several things concerning the attitude of workmen with regard to the bonus system, which may be of interest to your readers. It has always been my idea and has been the policy of the company, that good men should receive higher wages than the poorer men. In trying to carry out this policy, we encountered the strongest kind of opposition from labor unions, to the extent that we had a prolonged and bitter strike.

In the many discussions which preceded, and were held during the strike, the attitude of the union men was very clearly brought out: Their motto was "Absolute Equality," and they held out to the last for this. While they admitted that good men were deserving of higher wages than poorer ones, they contended that as soon as the varying scale of wages was put into practice, there would be constant friction and irritation, because the men who receive less than the maximum rate, would be dissatisfied, and try, by slighting their work and by other improper means, to appear to do as much as the better-paid men, and thereby secure the better wage.

When the strike was finally settled an agreement was entered into which provided for a varying scale for different classes of work, the company guaranteeing a minimum rate, and under certain circumstances a bonus of so much a piece over a stated amount. The arrangement as carried out apparently proved satisfactory to the workmen, and was entirely so to the company.

For several reasons we do not exactly divide with the workmen the profits which result from an extra amount of work done above the stated quantity. The employer of labor takes the responsibility of guaranteeing workmen a minimum rate per day, however many pieces they turn out less than the standard; and their wages continue also during the short breakdowns of plant, and during changes from one job or kind of work to another. The employer has a standing among business houses which no association of workmen could acquire. He is financially involved in his plant in a way which 6% interest does not begin to cover. He has to advance money or credit for materials which the workmen handle and which they could buy for themselves in but few cases were they so disposed. And there are other reasons which one can think of along this line. I do not, therefore, agree with Mr. Richards, that the work turned out by the extra exertion of the men brings the proprietor any more profit than that done up to the standard.

I believe in being eminently fair to workingmen, but an individual selling either his own labor or a manufactured product cannot have the standing and cannot expect the returns which an association or corporation doing a larger business ought to expect.

Yours very truly,
E. P. Goodrich, Chief Engineer.

Bush Terminal Co., Coffee Exchange Building,
New York City, Feb. 28, 1903.

Salaries of Geologists, Topographers and Others of the U. S. Geological Survey.

Sir: A reply to the question of Mr. Charles P. French in your issue of March 5 relative to the pay of geologists on the U. S. Geological Survey, though verbally correct, is somewhat misleading, and I would be glad to have you insert this more detailed statement:

One hundred and seven geologists and assistant geologists are connected with the Geological Survey, holding appointments from the Secretary of the Interior. Of these only four draw salaries which are fixed by law. The average of these four salaries is, as you state, $3,425. Thirty-six geologists and assistant geologists hold "temporary" appointments, although these appointments do not differ in actual permanency from the four fixed by law. The average annual salary of these 40 geologists and assistant geologists is $2,192.50. This is merely an arithmetical average, but as the various grades from $1,000 to $4,000 are fairly evenly represented, it gives a close approximation to the average pay.

The remaining 67 geologists and assistant geologists receive per diem compensation. These men are mostly college professors who are employed during only a portion of the year. The average pay of a per diem man is $5.70 for each day actually employed. Very respectfully,

C. W. Hayes,
Geologist in Charge of Geology.

Dept. of the Interior, U. S. Geological Survey,
Washington, D. C., March 7, 1903.

Sir: On page 218 of Engineering News for March 5, I note your answer to the question concerning the salaries of members of the U. S. Geological Survey. In it reference is made to the items appropriated for specific salaries. These, however, form but a small proportion of the salaries paid, since most of these are from lump appropriations for certain classes of work.

As the Survey employs a considerable number of young men and offers opportunities for others to enter upon scientific or engineering work, it may be desirable to give at this time a little more complete statement on this point The principal operations of the Survey are divided into three groups which for administrative purposes are termed respectively the Geologic, Topographic and Hydrographic branches. In each of these a considerable number of young men are taken out each year and are subsequently graded according to the skill or ability displayed. The men of the lower grades are designated as "aids," the compensation ranging from $60 to $75 per month. After a year or more of service they are put on an annual salary of $1,000.

The intermediate grades are known as "assistants" and the annual salary is $1,200, $1,400 and $1,600, advancement being made after a year or more of service at each of these grades.

After a period of say five or more years from graduation from college or technical school the assistants attain the full title of the branch in which they are employed, as geologist, topographer or engineer. The pay for the full grades is $1,800, and from this upward according to the responsibility of the position, the salaries reaching $2,400 or $3,000 or more for the higher positions.

The Register of the Department of the Interior gives full information on these points. Generalizing from this and other facts the following table has been prepared:

GEOLOGIC BRANCH.		
Aids	8 at	$1,000
Assistant geologists	2 "	1,200
Assistant geologists	3 "	1,600
Geologists	4 "	1,800
"	5 "	2,000
"	2 "	2,400
"	9 "	2,500 to 3,600
TOPOGRAPHIC BRANCH.		
Aids	2 at	$720
"	3 "	840
"	10 "	1,000
Assistants	5 "	1,200
"	11 "	1,400
"	13 "	1,600
Topographers	15 "	1,800
"	12 "	2,000
"	4 "	2,200
"	9 "	2,500 to 3,600
HYDROGRAPHIC BRANCH.		
Engineering aids	6 at	$720
" "	12 "	900
" "	14 "	1,000
Assistant engineers	14 "	1,200
" "	10 "	1,400
" "	12 "	1,600
Engineers	8 "	1,800
"	8 "	2,000
"	10 "	2,200 to 3,500

All of the above are in the classified civil service, but there are in addition a considerable number of men employed temporarily as their services are needed in the field. Certain requirements must be fulfilled with regard to these men; that they shall be competent and willing to devote a sufficient time to finish the work assigned to them. Preference is given to men who are making the particular subject a life study.

Civil service examinations are held at short intervals for geologic, topographic and hydrographic aids and assistants, full information concerning which can be had from the Civil Service Commission, Washington, D. C.

Very truly yours, F. H. Newell,
Chief Engineer.

Dept. of the Interior, U. S. Geological Survey,
Washington, D. C., March 6, 1903.

Shearing Stresses in Concrete-Steel Beams.

Sir: Owing to rather a prolonged absence from the city the writer is somewhat behind in his examination of current literature, otherwise he would have made earlier comments on the article by Captain Sewell, entitled "A Neglected Point in the Theory of Concrete Steel," in Engineering News of Jan. 29.

Captain Sewell is right with regard to the importance of the shearing stresses in the beam and the possibility and desirability of designing the beam to take care of such stresses. He is wrong in the statement that the American steel-concrete men have not realized the existence of these stresses and that their designs have not provided for them. The writer, as engineer for the St. Louis Expanded Metal Co., has, for many years, been aware of the importance of taking care of these stresses. His practice is, for such comparatively shallow beams as exist in flat slab-floor construction, to pass at least one-half of the bars over the beams, hooking them around the opposite side of the flange. The bars begin to rise toward the top of the beam near the quarter point. These bars cross what would normally be the angle of rupture and are of great assistance in increasing the strength of the construction. In deep beams, what we call shear bars are used, being, perhaps, ⅝-in. square bars passing vertically through the beam, spaced quite close together near the abutments, the space increasing toward the middle of the beam. These same shear bars were employed in the tests made by Thaddeus Hyatt at Kirkaldy's Laboratory in 1876, and the results were given in a book written by Hyatt and published in 1877.

Also, with regard to the theoretical treatment of the shearing stresses, Mr. Sewell is unnecessarily severe on the American engineers. It is true that they have said very little in the technical journals or even in their advertising literature about this phase of the question, partly because, perhaps, they may have wished to give the subject more thorough investigation, largely on account of their being too busy to write for publication. The writer has recently inserted a discussion of the shearing stresses at the end of the beam in a new catalogue that his company has now in press which will tell when shear bars are necessary and the statement is made therein that an increase in capacity of 50% can safely be depended upon by their judicious use under such circumstances; but no rule is given practically or theoretically for the determination of the number of shear bars that would be required and the method of arrangement of the same. It would be very difficult, indeed, to do this. There never has been made any investigation of what might be called the stress-strain shear diagram for concrete; this would probably be necessary before we could obtain a theoretical discussion enabling us to proportion the shear bars in a beam. These bars transpose some of the shearing action into endwise compression on the side of the bar, but how much stress in compression could be assumed to act before the full shearing strength would have been developed, it would be at present impossible to say. We only know that from practical experience certain designs have proven sufficient and that certain other designs have been insufficient.

There is one and only one matter of real importance concerning which the writer would differ with Mr. Sewell; that is, regarding the relative values of friction and adhesion. The former he places at 500 lbs. per square inch and the latter at 50. If such were the case, the statement following to the effect that it would be "absurd to suppose that any ordinary impact or vibration could so increase the tension in the steel as to overcome the skin friction; the steel would part first," would be warranted; but, in the writer's estimation, the above values should be reversed. He has made some tests on plain rods imbedded in concrete wherein the adhesion was intentionally broken by giving the bar a few blows on the end with a hammer; the specimens were then put in the testing machine, a washer being placed under the concrete prism and the bar pulled out. The frictional resistance varied from 16 to 24 lbs. per square inch. The concrete was 1:2:5 rock concrete 28 days old. If it were not for the deductions made, the writer would think that Captain Sewell's values had been accidentally transposed.

The adhesion has been found by numerous investigators to be quite high, but there are many ways in which it can be seriously injured, if not wholly destroyed, and one of these is by shocks and vibrations; and one very large example of this has come under the writer's notice. This was a building used for manufacturing purposes, the product being stored in barrels two high. The spans were 8 ft., the construction being flat bars about 1 × ¼-in. imbedded in ribs 6 ins. deep and 12 ins. apart, the ribs not being rectangular in section, but the underside of the floor being wavy like corrugated iron. It was the general practice in the warehouse to dump the barrels off on the floor from the top row, the material being light, the barrel and its contents not weighing more than 75 to 80 lbs. At the time the writer examined the building, it had been in use for eight years and the floors were in very bad condition; two panels had fallen through entirely, and the other panels were greatly deflected; the concrete beams were cracked underneath in the middle and on top near the supporting beams. The concrete when broken off on the underside of the ribs seemed to always split where the bar occurred as though there was no bond of any sort at this point. These floors were capable of carrying, originally, at least 1,200 lbs. per sq. ft., and had carried as a test load 800 lbs. without injury. In the

writer's estimation there is no explanation for the failure, except that the adhesion had been totally destroyed between the concrete and the metal and the floor was capable of carrying no load until it deflected enough to make the bars which had been hooked over the top of the beams act as hog chains.

The writer's company originally started with plain bars as concrete reinforcement in floor construction, but it was very quickly abandoned for the reason that when the test spans were built and tested to destruction it was noticed that the concrete always split where the bar occurred rather than at the section just outside, which should really have been weaker if the adhesion was so much greater than the cohesion as was commonly supposed at that time. We then made some tests, imbedding plain bars in concrete and seeing how much of a blow would be necessary to break the adhesion. We found that for ¼-in. square bar imbedded 6 ins. in rock concrete 28 days old, that a 1-lb. weight falling five times the distance of 12 ins. would drive the bar an appreciable distance through the concrete and when pulled out of the testing machine would withdraw under a load of between 100 and 150 lbs.

In view, therefore, of the tests and experience of the writer, it is impossible for him to believe that the skin friction is ten times as much as the adhesion and if any such high value for the friction was obtained it could scarcely have been on a plain bar; in other words, it was probably not the friction of concrete on metal, but very possibly concrete on concrete.

The writer would like very much to have Captain Sewell explain this point more fully as it is a matter of importance. If the values that he gives are correct, then a plain bar would be a perfectly reliable thing to use in concrete construction; but, if the adhesion, which is likely to be injured in various ways—and this, no doubt, Captain Sewell would admit—has the high value, and the friction is not over 50 lbs. per sq. in., as the writer believes to be the case, then it is highly important that the material be of such a nature as to give a perfect bond independent of the adhesion. Yours very truly,

St. Louis Expanded Metal Fireproofing Co.,
A. L. Johnson, Company Engineer.

Century Building, St. Louis, Mo., Feb. 27, 1903.

(We believe our correspondent has misunderstood Captain Sewell's somewhat ambiguous term "skin friction." As we understand it, Captain Sewell meant by this term the adhesion of the cement to the steel to resist a longitudinal force exerted to tear the two apart. Thus, suppose a flat steel bar imbedded in a block of concrete. Captain Sewell means that it would take ten times the force applied to the end of the bar to pull it out of the concrete that would have to be applied to separate the concrete from the bar by a force at right angles to it. Proof of the above letter was submitted to Capt. Sewell and his reply follows:—Ed.)

Sir: The proof of Mr. A. L. Johnson's letter relative to the writer's contribution in Engineering News of Jan. 29 has been received and read with great interest. The writer is sorry if he seems to have taken an extreme stand on the subject of American engineers and their apparent failure to take account of shearing stresses in concrete steel. He is quite prepared to apologize to those to whom it is due, but certainly American engineers have not contributed much to our rather scant knowledge of this subject, and the fact remains that many of them still deny the utility of vertical reinforcement altogether. Probably no one is in possession of a complete theory on this subject, but it would seem that the sum total of available knowledge would grow more rapidly if it were freely discussed in its preliminary stages, even at the expense of a few mistakes and wrong deductions; a partial solution, if correct as far as it goes, is a step in advance, at any rate. A rigid theoretical discussion of the problem is probably impossible, but a few well-conducted experiments ought to lead to empirical rules and formulas which would be sufficiently exact to serve as a basis for safe, economical and even scientific designs.

By the term "skin friction" in the article of Jan. 29 was meant the sum of all those forces tending to prevent the steel, when under stress, from slipping *longitudinally* in the concrete. Probably "tangential adhesion" would be a better name for it. The value of 500 lbs. per sq. in. is somewhat below the average of the values obtained by Professor Hatt in his tests on round bars bedded in concrete. A number of similar experiments that have come to the writer's notice, from time to time, seem to indicate that this is a conservative figure. The following results on twisted bars, kindly furnished by Mr. E. L. Ransome, are submitted in this connection:

Concrete: 1 cement, 2 sand, 3 stone. Five months old; made Oct. 26; tested March 26.

1. 1×1-in. cold twisted bar, embedded 2 ft. 6 ins. sustained full effort of hydraulic ram (35 tons), without yielding. Tangential adhesion at least 583 lbs. per sq. in.
2. 1×1-in. cold twisted bar embedded 1 ft. 6 ins. gave signs of slipping at 22 tons. Tangential adhesion, 611 lbs. per sq. in.
3. ½×½-in. cold twisted bar, embedded 1 ft. 6 ins.; upset head pulled off at 7 tons. Tangential adhesion certainly greater than 388 lbs. per sq. in; full value not determined.
4. ½×½-in. cold twisted bar, embedded 9 ins.; bar pulled apart just outside of concrete, at 8 tons. Tangential adhesion certainly greater than 888 lbs. per sq. in.

The above results may have been influenced by the twisting, though the writer doubts whether this influence is very great, as he has seen both twisted bars and plain bars loosened by shock and vibration, and while the applied forces were not measured, there seemed to be little difference between the two kinds of bars.

The writer has just received a copy of the new catalogue referred to by Mr. Johnson, and it is worthy of note that Mr. Johnson deduces a value for the shearing strength of concrete not so very different from the value herein placed on the tangential adhesion between the steel and the concrete. It is only fair to say here, that Mr. Johnson and his company are to be congratulated on the enlightened policy they pursue, in discussing the principles underlying their designs, with such perfect frankness as they do.

It inspires confidence in their methods and results, and can hardly fail to appeal strongly to all who are seriously desirous of raising the standard of design and workmanship in the engineering features of modern buildings.

Yet, even Mr. Johnson seems to miss part of the point raised in the article of Jan. 29. The writer has endeavored to get possession of a copy of the Hyatt-Kirkaldy tests referred to by Mr. Johnson, and has not succeeded; but, from such references as he can find to Hyatt's work, he infers that the shear bars were short vertical bars passing through holes in the horizontal tension bars. These bars, as well as those described by Mr. Johnson, do not quite meet the requirements of the case although of undoubted utility. They would probably answer every purpose if there were a large mass of concrete below as well

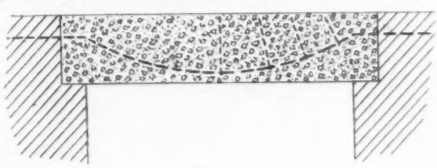

Fig. 1.

as above the horizontal bars, and the shear bars extended from top to bottom of the beam.

To make this matter clear, refer to Fig. 1 herewith. Assume a concrete beam reinforced with a bent tension bar, as shown; assume the tension bar anchored at its ends so it can act as a suspension bridge cable; suppose that the form shown is a true equilibrium curve for any assumed method of loading. Then, under this load, the bar will act in simple tension, and if strong enough, will carry the load regardless of the concrete. There will be no tendency to slip beyond that due to the elongation of the bar. The concrete, in this case, may be regarded merely as a means of applying the load. But suppose the form shown is not the true equilibrium curve for the assumed method of loading. Then the bar will undoubtedly tend to change its form; this will create a tendency to force off the concrete below it, by pressure approximately at right angles to the bar; there will be a tendency for the bar to separate from the concrete above at some points, and to hug it more closely at other points. This may result in failure, which would be very apt to exhibit itself as a failure under shear. Now suppose the bent tension rod is tied to the body of concrete above it by stirrups, such as are indicated on the right half of the diagram. Certainly the beam as a whole will be much stronger under varying loads, and the stirrups will counteract the tendency to force off the concrete below, up to the limit of their strength, or the holding power of the concrete above. But to accomplish this, they must be so formed as to pass around the bent tension bar, preferably with a reasonably close fit.

If there were a larger mass of concrete below, so as to give plain straight shear bars a good hold below as well as above, stirrups would not be required; but no practicable design would furnish such conditions. Taking the case of a perfectly straight horizontal tension bar, it is not a true equilibrium curve under any system of loading, and the tendency to force off the concrete below is a maximum. Bending the bars upward near the points of support lessens the evil, and in flat floor slabs of moderate span, is all-sufficient. But in beams of long span, nothing but stirrups will produce the maximum efficiency.

Horizontal tension bars and vertical stirrups, together with the concrete, virtually make up a truss, in which all tension in both web and chord is carried by steel members, and all compression by the concrete; the tangential adhesion supplies the connections. In any case, it is well to incline some of the chord members upward near the reactions, beginning, as Mr. Johnson does, at about the quarter points of the span. This will greatly reduce the necessary cross-section of the stirrups.

It is undoubtedly true that the tangential adhesion can be destroyed by shocks and vibrations; but when it is, the sructure is no longer safe, no matter what form of bar is used. The design should be such that ordinary fair wear and tear could not do such damage. The writer is inclined to think that the cases of failure described by Mr. Johnson in both the building and his tests, might not have occurred as they did had stirrups been used. As for the suitability of plain bars for concrete steel structures, there are too many successful examples of their use to leave any doubt on this point. However, it is more than likely

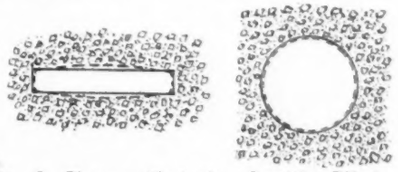

Fig. 2. Diagram Illustrating Possible Effect of Shrinkage of Concrete During Setting Upon Tangential Adhesion to Steel.

that both twisted bars and corrugated bars are better; they certainly have a higher elastic limit, and the corrugated bars would afford an admirable hold for the stirrups; but the corrugations would not cure the tendency to force off the concrete below in a direction normal to their length, and this tendency undoubtedly exists.

In this connection it is possibly worth while to state that the writer has for some time suspected that the tangential adhesion on round bars and small square bars, has a higher unit value than on other plain shapes—especially those presenting any considerable area of flat surface. He has often noticed that when bars of rectangular cross-section were knocked loose from surrounding concrete, the adhesion seemed greater at the corners than elsewhere; this was especially marked in the case of broad flat strips. This observation has been confirmed recently by an engineer of his acquaintance who made some tests that accord with the hypothesis, though not enough to prove it. The writer suggests that, if true, it may be explained by the accompanying diagrams, in which the full lines indicate the surfaces of the embedded bars, and the dotted ones the form which the adjacent concrete surfaces possibly tend to assume, during setting and shrinkage. They are much exaggerated, of course. There has been no opportunity to thoroughly test the coundness of this assumption, but it is offered for what it is worth.

The writer would like to explain that although twisted bars appeared in the photographs of tests published in his article of Jan. 29, so far as he knows, Mr. Ransome, the patentee of the cold twisted bar, was not responsible for the design of the floor sections tested.

Very truly yours, John Stephen Sewell,
Captain, Corps of Engineers.

735 No. Capitol St., Washington, D. C., March 9, 1903.

Notes and Queries.

In our Construction News Supplement of March 5, we published a report from Nashville, Tenn., stating that high water had carried away three bridges on the Tennessee Central R. R. We are now informed by Mr. W. N. McDonald, Chief Engineer of the company, that the item was incorrect. The only damage done was the washing out of two bents of a frame trestle due to the breaking of a private dam, and the washing out of three bents of another frame trestle due to insufficient size of a culvert under a parallel railway only 60 ft. from the trestle referred to.

"Division Engineer," Montreal, P. Q., writes:

Will you kindly advise me if you know the names of any railroads in the United States which are using the Latimer rerailing guards for bridges, and where I could get information as to details of construction and cost of this guard?

This subject was pretty thoroughly threshed over in the columns of Engineering News 15 years ago. The guard was invented by the late Chas. Latimer and patented April 8, 1873. The patent was sold to Mr. W. J. Morden, of the Morden Frog & Crossing Works, of Chicago, and expired in 1890. Drawings of Latimer guards as used on various railways were published in our issues of Sept. 13, Oct. 4, Nov. 1 and Dec. 27, 1890, and in March 7 and April 11, 1891.

As to the present use of the Latimer guard on American railways, our impression is that the use of outside guard timbers and inside guard rails with the outside guards flared at the ends and the inside rails brought to a point is almost universal. While rerailing frogs are frequently used in connection with these guards, they are also often omitted, but we know of no reason save mistaken economy why they should not always be installed.

A PIPE FORCING JACK DESIGNED TO OBVIATE TRENCHING.

Where the character of the soil will permit it is sometimes both more convenient and economical to force small pipes into place horizontally instead of digging a trench and laying them in the usual manner. The accompanying illustration shows a 3-in. pipe being forced beneath four railway tracks by means of a pipe forcing jack, made by the Duff Manufacturing Co., of Allegheny, Pa. As may be seen by the view, the device consists of a cage, moved along a rack by means of a

socket lever and pawls. The rack, and also the two pipe guides, are bolted to a plank.

The cage of each jack is provided with a groove and clamp for holding ¾ to 4-in. pipe. The rack teeth are machine cut. As ordinarily made, the rack requires pipe to be cut in lengths of 7½ ft., but longer racks can be provided. For the driving end, a section of pipe 2 or 3 ft. long, larger than the pipe being laid, is recommended, and at the very front of this it is well to attach a coupling, with a cutting edge. A jack with a 7½-ft. rack weighs 185 lbs., and is said to have a "capacity" of 15 tons (total pressure exerted?). It is also stated that pipe has been forced a distance of 150 ft. by means of this device.

JACK FORCING A 4-IN. PIPE BENEATH FOUR RAILWAY TRACKS.

COMMITTEE REPORTS AT THE CONVENTION OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.

As a preliminary to a report of the convention held at Chicago on March 17 and 18, we give herewith abstracts of some of the reports presented at the meeting:

Yards and Terminals.

In conformity with the principles governing its previous work and reports, your Committee has undertaken to define or outline the rules and principles which should primarily be considered in the design of yard and terminal facilities, and also to give general descriptions of the various important features of such facilities. Two subjects in particular have been taken up for special consideration in this report: 1, terminal yard and general switching; 2, water and rail terminals.

TERMINAL YARD AND GENERAL SWITCHING.

The distance from the large general yard or cluster to the docks, wharves, freight houses, team tracks or other facilities is in some cases as much as 15 or 20 miles. This territory is divided into districts, for convenience in switching and for the assignment of switching crews. Each switching district is usually provided with a small switching yard, from which the various private sidetracks, freight houses and manufacturing establishments in the district are supplied with their cars. The district yard is supplied and relieved by movements to and from the cluster or general yard.

CAR RECORDS.—In view of the per diem system, which is something new in railway service, a system devised by the Philadelphia & Reading R. R. may be described. At a large terminal it is almost absolutely necessary, in order to keep the matter in check, that a system be in force which will serve as an object lesson to the men. To accomplish this a ticket for every foreign car, as it arrives, is placed in a case made for the purpose and kept there until the car leaves the yard, when the ticket is taken out and destroyed. The ticket need only be a small blank card, on which may be written the car number, initial and date of arrival.

This per diem case is divided into 310 pigeonholes, numbered from left to right from 1 to 31, indicating the days of the month. On the sides of the case are the ten numerals. As soon as a foreign car arrives in the yard a blank ticket is filled out as above and placed in the case under the number indicating the date and on a line with the numeral which corresponds with the last figure in the car number, thus: Car L. V., 41947, arriving July 26, would be placed in column 26 on line No. 7.

Very good results are possible from the use of this case. Without consulting any books or records of any kind it is possible, by a glance at the case, to tell just how long cars are being held, and in a few minutes, by simply counting the tickets, it is possible to tell how many cars are being held subject to per diem charges. Different colored slips should be used for each month to assist in promptly locating cars which arrived during the previous month, and which should be given attention.

THE PLANNING OF YARDS.

In designing the arrangement of tracks for any of the yards at a terminal it is important that the engineer should study the movement carefully as regards volume, kind, the hours at which it is made, etc.; he must take into consideration the interference to freight movement at the time it must contend with the passenger movement. It is also well to study with the trainmaster or other transportation official the entire layout of the tracks before they are constructed; the transportation department, which has to conduct the operations on the tracks, will frequently give most valuable suggestions as to the proper manner of arranging them.

WATER AND RAIL TERMINALS.

At large marine terminals—whether ocean or lake ports—the railway facilities for handling business differ very materially from those of the inland terminals previously described, and the facilities needed to properly handle the business at the point of connection of the rail trip and the water trip are different from those already described. At such terminals it is advantageous to unload into warehouses all classes of freight which can be placed on platforms, and only retain in the cars such classes of property as cannot be provided with housing accommodations. The great bulk of export and import freight is moved by lighterage service of the terminal railway company. Where it is the practice to bring the ocean vessel to the dock of the terminal company, the agent has preliminary advice and is guided accordingly. The maintenance of special warehouses for export freight is not always essential, but the general warehouses employed for the unloading of lighterage freight can often be used also for export freight which is delivered direct to the vessel.

It will facilitate matters if these warehouses are skirted with tracks on the outside, which, in turn, may be used to unload to or from the car, in addition to securing freight from the warehouse or discharging thereon. Greater economy in labor necessarily results if loading directly to and from the car can be brought about, and in a greater measure this suggestion permits either process to be employed in serving a vessel. A series of open docks are also essential for the handling of coarse freight, and also to extend the hoisting facilities operated by the terminal company in the interest of such vessels as have no means of taking on or discharging a cargo with their own power. In fact, open docks can be employed successfully for general cargoes usually loaded in box cars and the general trade transacted with small vessels and barges.

The facilities provided at large seaport terminals are generally as follows:

(1) A cluster or general yard, into which trains are moved; (2) lighterage piers, either open or covered, from which cars are unloaded or loaded to and from vessels; (3) export piers, from which freight for export is unloaded and transferred from vessels, or vice versa; (4) storage piers, in which is held (preparatory to being loaded on vessels) such freight as flour, machinery, lumber, provisions, canned goods, etc., the traffic rules allowing quite an amount of free time on this class of commodities; (5) inbound and outbound freight station piers, located at points where they are only reached by water, and cars are moved to and from them on car floats (these are used for the city delivery or receipt of freight), and team track delivery yards are provided in connection with them; (6) coal piers, upon which cars are run and unloaded into coal barges or vessels; (7) grain elevators; (8) warehouses; (9) stock yards.

COVERED LIGHTERAGE PIERS.

These should be about 600 ft. long and about 125 ft. wide, with two tracks in the center, built at such an elevation that the floors of cars will be level with the deck of floor of pier. It is sometimes recommended that the sides of the pier should be composed entirely of iron rolling or folding doors, but on consideration this feature does not seem to be desirable. It cuts down the storage space and very frequently it will be found that the post between two doors will obstruct one gangway to a lighter. Most lighters have but two gangways, and where a railway company handles the bulk of its lighterage business the lighters are usually built with a standard spacing for the gangways, so that the doors of the pier can be spaced to accommodate the gangways. There should be a platform 4 ft. wide, outside of the walls, on the three water sides of the shed, the platform being provided with mooring piles or posts for securing vessels. Many of the older piers were built with sides having an inward slope or batter of about 1 in. per ft., or usually about 3 ft. in the height. This was done so that in loading or unloading lighters the packages would not strike the sides of the building. This contingency is better provided against, however, by making a wider platform outside of the building, and practically all modern pier sheds are built with vertical sides.

RAMPS.—Where heavy tides occur, adjustable ramps or inclines should be introduced in the floor, the outer edge of the ramps being in line with the edge of the pier. By these means freight may be trucked to and from lighters at any stage of the tide without serious interference. The ramps are usually 15 to 20 ft. in length, fitted with counter-weights and worked by a worm gear. Fixed ramps are sometimes used for convenient access to the lower decks of vessels.

OPEN LIGHTERAGE PIERS.

These should be about 35 ft. wide and 600 ft. long, with a 6-ft. platform along each side. In many cases only two tracks are used, but long piers or piers which have more than two berths along each side should have a third track, connected with the others by crossovers. This facilitates the shifting of cars and enables the berths at the outer end of the pier to be served without disturbing the work that is being done at the other berths. A pier with three tracks should be 45 to 50 ft. wide, and with tracks at least 11 ft. 6 ins. c. to c. The floor of the pier may be depressed so as to bring the car floors level with the 6-ft. platforms on each side. This, however, is not usually done.

The piers should be so located that cars will feed directly to and from the proper part of the cluster or general yard with the minimum amount of interference. The pier is principally used for the handling of coarser products moving in gondola or flat cars. It is the type best adapted for the handling of such business as will not have to be unloaded and held or stored on the pier.

EXPORT AND STORAGE PIERS.

Under the traffic rules export freight has to be held free of storage for 60 days. This is done to provide time for the arrival of steamers, or to make arrangements for the shipments. An export pier should be about 600 ft. long and about 125 ft. wide. On account of the great height of ocean steamers, it should usually be double-decked: first story, 20 ft. head room; second story, 18 ft.; height at eaves, about 43 ft. The pier should be surrounded with a 6-ft. platform, arranged with the proper number of mooring piles for tying up vessels.

If possible, at least one track should be provided on the upper floor. In any case, there should be a proper number of elevators for moving freight from floor to floor.

The double-deck pier has a number of advantages over a single deck. The foundations are little, if any, more expensive, and it has approximately double the floor space, while, comparing floor space with roof, the cost of roof is only one-half that of a single deck. The amount of real estate required is only about one-half. These advantages are very great when the enormous value of terminal real estate is considered. Very frequently the second story of these piers is so arranged that immigrants can be handled.

The storage pier has many of the features of the covered lighterage pier, but is designed primarily to accommodate the large ocean-going steamers, while the other pier is built to store only goods for harbor lighters. The export pier is for the handling of general export business.

in the case of flour, which usually has to be held a long time, the pier should be several stories high, and the stories should be only about 10 ft. high in clearance. Cutting down the height of the stories saves in the cost of the building, and also in the labor of tiering up freight to a great height.

COAL PIERS.

These are really open lighterage piers so arranged that coal from hopper-bottom cars can be readily discharged into vessels and barges. This arrangement makes it necessary to build the piers at a considerable height above the water. Coal is dumped directly from the car into a coal pocket, from which the coal is led through a chute to the vessel. The chutes are so arranged that they can be lowered, raised or extended, and in this way can be made to reach the proper part of the vessel. Where hard coal is handled, it is necessary to furnish the chutes with screens for eliminating dust from the coal. A coal pier usually has three tracks. The outside tracks are occupied by the loaded cars. As these are unloaded, they are moved ahead and drop back to the middle track, which should be built on a grade falling toward the general yard, so that when the empty cars once get on to this track, they will feed naturally into the yard. The grade of the tracks on which the loads stand should be such that they will feed toward the outer end of the pier, to enable them to be easily shifted to the middle track. This arrangement of grades enables cars to be handled quickly, gives a greater capacity and reduces the cost of handling. Coal piers which are exceptionally long should have five tracks connected with suitable crossovers, so that cars can be moved around those which are unloading at any particular berth.

The above discussion relates only to the simple or elementary type of pier for handling coal. It is the intention of your committee to prepare a detailed report on coal piers, covering a number of different kinds in use in this country, and including also the various mechanical devices for lifting cars and dumping coal.

C. S. Sims, Gen. Supt. B. & O. R. R.; W. G. Besler, Vice-Pres. and Gen. Mgr. C. R. R. of N. J.; J. A. Atwood, Ch. Engr. P. & L. E. R. R.; M. S. Blaiklock, Supt. G. T. Ry.; J. B. Cox, Ch. Engr., C. J. Ry.; E. P. Dawley, Div. Eng. N. Y., N. H. & H. R. R.; G. F. Morse, Asst. Engr. L. V. R. R.; Nettelton Neff, Engr. M.-of-W. Penn. Lines; F. S. Stevens, Supt. P. & R. R. R.; A. W. Swanitz, Cons. Engr.; E. E. R. Tratman, Res. Ed. Engineering News.

Wooden Bridges and Trestles.

Wooden trestles have served their purpose for many years, and made possible the construction of roads and railroads which might not otherwise have been built, but it is probable that they will eventually give way to more permanent structures built of steel, stone, or some other equally durable materials; yet wooden structures are in many cases advisable and necessary, and will doubtless be used to a greater or less extent on all railroads for many years. The plans and specifications submitted herewith, particularly in so far as they specify definite sizes and dimensions, are not recommended for universal adoption, but are presented as purely typical and representing a fair average of the practice of the day. Local conditions, past practice, traffic, locality, climate, etc., must determine such variations in these plans and specifications as in each individual case may seem wise.

SPECIFICATIONS.

Proper surface of the track is to be secured by carefully framing and adjusting the lengths of the posts or piles in the bents; and where super-elevation is required for the track on curves, it shall be made in the lengths of the posts or piles, the cap being inclined to correspond.

MATERIAL.—Lumber should preferably be white pine, long-leaf Southern pine, Douglas fir, or white and burr oak, cut from live trees, and sawed square in section, free from wind shakes, large or unsound knots, any defects that impair its strength, and generally free from sap wood. Piles should preferably be cedar, native white or burr oak, heart cypress, long-leaf Southern pine, Douglas fir and white pine.

LENGTH OF SPANS.—All spans to be 14 ft. c. to c., except end spans, which shall be 13 ft. 6 ins. c. to c., using stringers of two span lengths. Where longer stringers can be economically obtained, longer spans may be used.

FOUNDATION.—The foundation for framed trestles may be piles, wooden sub-sills, or masonry.

SILLS.—Sills for framed trestles will be 12 × 12 ins., securely drift-bolted or anchor-bolted to the foundation.

POSTS.—Posts shall be 12 × 12 ins., properly framed and secured with drift bolts or dowels; the outside posts to be battered from 2 to 3 ins. in 12 ins.

CAPS.—Caps to be 12 × 14 ins., 14 ft. long, and drift-bolted to posts or piles with ¾-in. drift bolts.

SWAY AND SASH BRACES.—The bents to have 3 × 10-in. sway and sash braces, fully secured with ¾-in. bolts or boat spikes at each point of contact.

LONGITUDINAL STRUTS OR GIRTS.—To be 6 × 10 ins., notched 3 ins. over intermediate sills, and secured with ¾-in. drift bolts.

LONGITDINAL X BRACING.—To be 3 × 10 ins., there being at least three lines in each panel.

STRINGERS.—There will be three lines of 8 × 16-in. stringers (long-leaf Southern pine or Douglas fir preferred) for each rail, laid with broken joints and bolted together with ¾-in. bolts and cast-iron packing spools. The stringers to be secured to the caps with two drift bolts for each cap.

TIES.—To be 8 × 8 ins., 10 ft. long, sized over the stringers. Two ties in every panel to be bolted to the stringers and every alternate tie spiked to stringers with ½ × 12-in. boat spikes.

GUARD RAILS.—Guard rails to be 6 × 8 ins., laid flat, and notched at least one inch over the ties.

BULKHEADS.—To be of good old timber, cut to the slope of the bank to hold the earth or ballast.

Where lumber or piles are treated by some approved method, other kinds of wood than those herein mentioned as preferable, also other methods of construction, such as solid wood ballast floor bridge, may be desirable.

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Roadway.

DRAINAGE.—This subject, it seems, has always received some attention, though often seriously inadequate. That suitable provision was made in cuts is clearly shown by the instructions given in 1828 to the Superintendent of Construction of the Baltimore & Ohio R. R.: "The width of side drains shall be not less than 3 ft., and in side cuttings where only one is required, its width shall be 5 ft. In all deep cuttings in earth, sand or gravel, where the depth of the cut exceeds 40 ft., a berme 6 ft. wide, including a drain 3 ft. wide, is to be provided for on each side of the cut, and in all situations where the bank of a deep cut is surmounted by an accilvity of any considerable extent, back drains of such dimensions as the superintendent may deem appropriate shall be formed in the natural surface of the ground or in rear of the spoil banks." Other provisions apparently look to under-drainage. If this be true, the drainage scheme was substantially complete as early as 1828.

It is probably true to-day that drainage, especially under-drainage, is attended to far less perfectly than its importance really demands. Subsoil drain tiles seem to have come into use on farms earlier than on railroads. In 1868, according to a paper before the Civil Engineers' Club of Cleveland, the Chief Engineer of the Lake Shore & Michigan Southern Ry. introduced tile drains, probably the first on American railways, as the result of a suggestion from a farmer. The ditches were 2 ft. wide and 3½ ft. below the bottom of the regular ditch, and in three years 45 miles of subdrains had been put in use on this road, with most favorable results.

METHODS OF WORK.—In relation to apparatus used in railway construction, the wheelbarrow and cart are of great antiquity. The common scraper, drag scraper or scoop scraper is somewhat older than is commonly realized. The notice or proposal to contractors for the Baltimore & Ohio Railroad in 1828 suggests that the materials excavated shall be transported "by means of barrows, scrapers, carts or other suitable machines." It appears, however, that the scraper was in common use on the Erie Canal, doubtless as early as 1817, the date of the first contract. Apparently scrapers at that early date were not new, but had already come into common use. The use of cars on temporary track certainly antedates the building of railways in this country, for in a pamphlet entitled "Facts and Arguments in Favor of Adopting Railways," it appears that "A wooden rail track, which has proved very efficacious, is at present in operation under the direction of the excellent engineer, Mr. Randel, for the purpose of removing the excavated earth of the Delaware & Chesapeake Canal, below Philadelphia." In England it was apparently very common procedure to build a bank out by pushing cars along a track and dumping over the end of the bank.

The use of trestles or "trussels" was practised on the South Carolina Ry. in 1832, and provision was made at that time for filling around the piles, for it is stated as follows:

> The execution of the work throughout this division of the line is of a very substantial and superior character, especially through the valleys of Horse and Wise Creeks, where extensive sections of the trussel work have been substituted for the piling construction. In some cases the elevation of the grade of road above the surface of the country rendered this mode of construction indispensable, and in other cases where the soil consists of soft mud ten or twenty feet below the natural surface, its adoption was judicious, as the most effectual mode of acquiring solidity of foundation and stability of structure. Yet it must be admitted that all piles will decay, and that decay commences at the surface of the earth. To guard against the consequences which must otherwise ensue, it is contemplated to fill up the ravines every year, in summer months, about 12 or 18 ins., so as to keep that part covered with earth in which the rot may have commenced.

This apparently was the beginning of the practice of building semi-permanent trestles, which were to remain until renewal was imminent, and then filling with earth, a practice which was certainly in extensive use in 1850, and perhaps much earlier. This practice may be considered as a part of the American policy of building temporary structures, to be replaced by permanent ones later.

The most effective instrument for excavation now in use is the steam shovel, and the Journal of the Franklin Institute in 1843 states in relation to the American steam excavator, or "Yankee Geologist," as it seems to have been called, that "The excavator has been employed for three years upon the Western Railroad and other places, and that this test showed an immense saving of expense," and it refers also to "two machines employed for two months in almost constant work in Brooklyn," the total work in two months being 92,593 cubic yards. This makes the date of its introduction the year 1840.

The apparatus for dumping, which has been associated with the steam shovel for many years, the ballast plow for unloading flat cars, is of considerably later date; its first use was upon the Southern Minnesota Ry. at or near Hokah, Minn., some time during the year 1867, the same year in which it was patented.

The earliest date that appears authentic for the introduction of the wheeled scraper is about 1870, when it was used on the St. Louis & Southwestern. There can be no doubt as to the fact, however, that a practical wheeled scraper was used as early as 1874, and that this apparatus was used extensively in 1878.

Grading machines, of the type often called road machines, came in about the same time. From excellent authority it appears that the first elevating grader was used in the fall of 1871. It was of the Wauchope type, used on a railway grade of a road known as the Chicago, Danville & Ohio Ry. The work was done in Cumberland county, Ill., three miles being built with the machine. These machines have been much improved in recent years, and for about two years traction engines have been used instead of horses to pull them.

For working rock, black powder has been used far back of railroad history. In 1823, however, a blast was first fired by the electric spark, and a few years later, 1829, in New York, several charges were fired simultaneously by the same agency, using fulminate of silver. In 1844 compressed air was used for working drill hammers, the air being useful also for tunnel ventilation. The year 1849 marked the date of the patent for the first percussion drill, and 1851 the first direct action drill of this sort. From 1856 to 1861 much experimenting was done, and power drills improved. The Hoosac Tunnel was the scene of considerable development for drills up to a point of definitely successful use, and there also nitro-glycerine was first used on this continent, in 1866, three years after its introduction on the other side of the Atlantic. Dynamite was invented in 1867, and patented in America a year later. It is unnecessary to follow the many variations in the way of explosives that soon followed.

SPECIFICATIONS.—There are innumerable forms of specifications in use or on paper to-day for the same class of work, many of which differ materially in essential features. Contractors soon discover the defective points of a specification, often previous to making their bid, and are concerned but little with restrictions or ambiguous clauses expressed therein, being quite aware that the courts have repeatedly decided that a contract to be binding must be fair to both parties; and that a specification, being the main feature of the contract, should contain nothing that could be construed to the disadvantage of either party.

It is the purpose of the specification attached to this report to provide for the construction of the roadway of a railroad on any part of the western continent. Of course, it is not intended that it should be adopted in the sense of being followed literally in every particular, by every railroad, the physical, climatic and commercial conditions in the vast extent of territory covered being so varied; but the object sought is to lay down some general principles which can be modified as found necessary to suit special conditions.

SPECIFICATION FOR THE FORMATION OF THE ROADWAY.

IN GENERAL.

1. The center of the roadbed shall conform in alinement to the center stakes set for it by the engineer.

2. The grade line on the profile denotes subgrade, and this term indicates the tops of the embankments and bottoms of cuttings ready to receive the ballast.

3. The roadbed shall be formed to the contour, slopes and dimensions shown upon the drawings attached to and forming part of the contract, or to such modifications thereof as are required to meet special conditions, or as the engineer may from time to time direct.

4. When finished and properly settled, the roadbed shall conform to the grade levels set for it, and shall be of the following dimensions at subgrade for single track: On embankments, 20 ft. wide; in excavations, 20 ft., and outside of this width the necessary ditches must be formed. For each additional track an additional width of 14 ft. shall be made.

5. The slopes of earth embankments to be at an inclination of 1½ to 1? embankments of rock, 1 to 1; earth or common excavations, 1½ to 1; solid rock excavations, ¼ to 1; loose rock excavations, ½ to 1.

These ratios may be varied by the engineer, according to circumstances, and the slopes shall be made as directed by him in each particular case.

CLEARING.

7. The whole of the land comprising the right of way and station yards, except any portions thereof that the engineer may reserve, shall be cleared of all trees, brush and perishable materials of whatever nature.

8. All these materials, with the exception of such as are hereafter mentioned, shall be burned or otherwise removed from the ground, as the engineer may direct, and without injury to adjoining property.

9. Where clearing is to be done, stumps shall be cut off even with the ground, except between the slope stakes of embankments, where stumps may be cut so that the depth of filling over them will not be less than 2½ ft.

10. The work of clearing shall be kept at least 100 yds. in advance of grading.

11. All trees which the engineer may reserve shall be stripped of their tops and branches, cut to such lengths as the engineer may direct, and be neatly piled at such places on the right of way as he may designate, for which service an allowance will be made of ———— per cord.

12. Fences, buildings and other movable property on the right of way shall be carefully removed and piled up for the use of the owner, as may be directed by the engineer, without extra charge, it being understood that the price for clearing covers these items; except that in lo-

calities where buildings exist in large numbers, a special price will be made for such work.

13. Measurement of clearing and payment for the same will be by the square of 100 ft. square, or fraction thereof actually cleared, but no payment will be made for clearing in borrow pits located outside the right of way.

14. In the case of isolated trees, the area to be computed and paid for as clearing shall be that covered by the overhang of the branches.

15. No allowance will be made for the burning or otherwise removing, as the engineer may direct, grain, grass or annual growths of any kind, it being understood that the contract price for grading covers this item.

GRUBBING.

16. Stumps must be grubbed entirely from all places where excavations occur, including ground from which material is to be borrowed, as well as from ditches, new channels for waterways and other places where, in the opinion of the engineer, it is necessary.

Grubbing will also be required between the slope stakes of all embankments of less than 2½ ft. in height.

17. The work of grubbing shall be kept at least 100 yds. in advance of grading.

18. Measurement of grubbing shall be estimated only upon excavations of 3 ft. in depth or less, and under embankments of 2½ ft. in height or less, and upon uniform ditches, whenever ordered by the engineer. Payment for the same will be by the square of 100 ft. square or fraction thereof actually grubbed, but no allowance will be made for grubbing in borrow pits.

GRADING.

19. The term "Grading" in this specification includes all ditching, diversions of roads and streams, excavations and embankments for the formation of the roadbed, foundation pits, and all similar works connected with or appertaining to the construction of the railway, its side tracks, spur tracks and station grounds.

20. All material excavated shall be classified as solid rock, loose rock or common excavation.

21. Solid rock shall comprise rock in solid beds or masses in its original position, and boulders or detached masses of rock of one cubic yard in bulk or over, which, in the judgment of the engineer, may be best removed by blasting.

22. Loose rock shall comprise all stratified rock which can be properly removed by pick and bar, of which the engineer shall be the judge, and detached masses of rock or stone of more than three cubic feet and less than one cubic yard in bulk, that can be removed without blasting, although blasting may, on favorable occasions, be resorted to in order to facilitate the work.

23. Common excavation shall comprise all other materials of whatever nature that do not come under the classification of solid rock or loose rock.

24. Slopes of all excavations shall be cut true and straight, and all loose stones in the slopes must be promptly removed.

25. In rock excavations the material must in all cases be taken out 12 ins. below subgrade, and refilled to subgrade with material approved by the engineer.

26. Excavation in excess of the cross-section authorized by the engineer, as well as slips, or subsidences extending beyond the slope lines, shall not be paid for, unless in the judgment of the engineer such are due to causes which are not the fault of the contractor or his agents. If such results are unavoidable, the surplus material shall be removed by the contractor without delay, and the slopes formed to the satisfaction of the engineer. The classification of the material shall be in accordance with its condition at the time of removal, regardless of prior conditions.

27. Where the quantity of excavation exceeds that required to make up the contiguous embankments to standard cross-section, the surplus shall be used to widen the embankments uniformly along one or both sides, as directed by the engineer, and no material shall be deposited in waste banks unless such waste be provided for on the profiles or else by written order of the engineer.

28. Where wasting is ordered, the material shall, if possible, be deposited below grade line, and under no circumstances shall the waste bank have its nearest edge within 30 ft. of the slope stakes of the cutting.

29. Where the quantity of excavation from the cuttings of standard cross-section is insufficient to form the adjacent embankments, the deficiency shall be made up by widening the cuttings on one or both sides of the center line, as directed by the engineer, and no material shall be taken from borrow pits, unless such borrow be provided for on the profiles, or else by written order of the engineer.

30. The quantities shown on the profile exhibited for distribution of material are approximate only, and will in no way govern the final estimate. The company reserves the right to increase or diminish the quantities given, without affecting the contract prices for the various parts of the work.

31. Where gravel, stone or any other material suitable for special uses of the company are met with in the excavations, the same may be reserved and deposited in convenient positions on the right of way, to the extent the engineer may direct, and other suitable material in the vicinity substituted as may be required to complete the embankments.

32. A berm of 4 ft. shall be left between the edge of rock excavations and toe of slope of overlying earth.

33. Intercepting ditches shall be made at the top of the slopes of all earth cuttings where the ground falls toward the top of the slopes, and they must diverge sufficiently to prevent abrasion of the adjoining embankment. The cross-section and location of such ditches will be designated by the engineer, and if required by him, shall be made in advance of opening the cutting.

34. Ditches shall be formed at the bottom of the slopes according to the cross-section shown upon the plans, or such modifications thereof as the engineer may direct; they shall be neatly made surfaced to true grade, and at the lower end must diverge sufficiently to prevent abrasion of the adjacent embankment.

35. Subdrains of tiles must be put in, of such sizes and location as the engineer may direct. Excavations for these drains must be taken out to below frost line, as directed, and made to proper grade; the tiles to be laid with ends abutting and covered with slough grass, hay or straw, over which shall be placed engine cinders or fine gravel to a depth of 3 or 4 ins., and the remainder of the trench filled with coarse gravel or broken stone.

Measurement and payment for such drains will be by the lineal foot, according to diameter of tile, including excavation and refilling, the contractor to find all the material for the same.

36. Excavations incident to the construction of the roadbed, ditches, channels and roadways shall be used in forming the embankments; but no unsuitable material or material whilst in a frozen state will be allowed to enter into their composition.

37. Wherever in the judgment of the engineer it is practicable, embankments shall be built in horizontal layers of from 2 ft. to 4 ft. in thickness, these layers to be of the full width of the embankment, and built to the true slope, without widening with loose material from the top. The materials shall be placed in such location as the engineer may direct, and the most suitable must in all cases be reserved for finishing the surfaces. Excepting in rock embankments, no large stones will be allowed within a depth of at least 2 ft. below subgrade.

38. Embankments shall be carried to such height above subgrade and to such increased width as the engineer may deem a necessary provision for shrinkage, compression and washing. As the embankments become consolidated, their sides shall be carefully trimmed to the proper slopes, and they must be maintained to their proper height, dimensions and shape until the work is finally accepted by the engineer.

39. When an embankment is to be placed on sloping ground, the surface shall be deeply plowed or stepped; and whenever directed by the engineer, boggy or unsuitable material shall be excavated from under proposed embankment, and the embankment in all cases started from a firm foundation.

40. In crossing bogs or swamps of unsound bottom, the engineer may require a special substructure of logs and brushwood, the logs forming this foundation to be not less than 6 ins. diameter at the small end. There shall be two layers crossing each other at right angles, the logs of each layer being placed close together, with broken joints and covered closely with brush, and they shall project 5 ft. beyond the slope stakes of the embankment.

Measurement of this substructure and payment for the same will be by the square of 100 ft. square, or fraction thereof, of ground area covered by the substructure.

41. In forming embankments to take the place of existing trestles, the material must be thoroughly compacted between the trestle bents, and around and under all parts of the structure, and in case of train filling from above grade by means of a temporary trestle, the material must be uniformly spread in the fill.

42. Embankments butting against the ends of trestle bridges shall be brought forward upon the structures a length of at least 6 ft., with an increased breadth of 2 ft., in order to form a full roadbed.

43. The top of embankments must be compact and finished to a true plane, and no depression left that would hold water.

44. In embankments over or about masonry or other structures the material shall be deposited in thin layers, and each layer carefully tamped. Special care must be exercised not to unduly strain these structures, and only the best of material available will be allowed for the purpose of such filling. The contract price for excavation shall cover the cost of obtaining, distributing and packing the material behind, over and around all such structures.

BORROW PITS.

45. Land for borrow pits or waste banks outside of the railroad property will be secured by the contractor at his own expense.

46. Borrow pits within the limits of the right of way shall be regular in width, and, if necessary, connected with ditches, and drained to the nearest water course. Material shall in no case be borrowed to a depth that will not permit of proper drainage. In prairie country the drainage through borrow pits may be omitted at the discretion of the engineer.

47. Side slopes of borrow pits on the right of way shall be of similar angle to the prism of the road. A berm of not less than 6 ft. in width shall be left between slope stakes of the embankment and the edge of the borrow pit, and a berm of not less than 3 ft. between the outside slope of the borrow pit and the right of way line. Berms must consist of the original unbroken ground.

48. Borrowing must be done in regular shape in order to admit of ready and accurate measurement.

49. Borrow pits shall not be excavated before they have been staked out and cross-sectioned by the engineer.

50. In land set apart for station grounds, or other special purposes, no borrowing will be allowed below grade, nor any wasting of material above grade, except by written directions of the engineer.

PRICE AND MEASUREMENT.

51. All grading shall be done and estimated by the cubic yard, at the prices specified for the respective materials. Measurement shall be made in excavation only, except in cases hereinafter mentioned.

52. The contract price per cubic yard will include the excavation of the material by any method whatever, the loading, transportation and deposit of the same in the manner described by this specification, and in the places designated by the engineer, the plowing or benching of slopes, as well as all other expense incident to the work of grading.

53. It is distinctly understood that the contract price per cubic yard covers any haul found necessary, and that there will be no allowance made for any so-termed "overhaul."

54. If in the opinion of the engineer any borrowed material can be more accurately measured in embankment, his work may be done in that manner, using the cross-section notes of the embankment prisms and making the allowance which in his judgment is just and reasonable, so that the quantities measured shall, as nearly as possible, equal the excavation quantities, had it been practicable to measure them in excavation; but this does not apply to rock embankments.

55. Rock embankments, if measured in embankment, will be paid for according to the number of cubic yards as shown by the cross-section notes of such embankment.

56. There shall be no classification or allowance made for loose or solid rock in borrow pits, it being the intent and meaning of this specification that all borrowed material shall be classified and paid for as common excavation, unless specific written instructions are given by the engineer to the contrary.

TUNNEL EXCAVATION.

57. Tunnels shall be excavated to the alinement and gradient shown upon the plans, or to such modifications thereof as the engineer may direct, and they shall conform as near as practicable with the standard cross-section, as shown upon drawing No. .....; the height and width to be designated in each case by the engineer, in order to meet existing conditions.

58. Tunnels which, in the opinion of the engineer, require lining with masonry or timber shall be excavated to the cross-section shown upon drawing No. ....., in order to give room for the lining and leave as small a space as possible to back-fill.

59. Bottom of tunnels shall be picked to a uniform surface, and no rocky protuberances will be allowed inside the general lines of the section.

60. Blasting shall be done with all possible care, so as not to damage the roof and sides, and all insecure pieces of rock beyond the contour lines shall be removed by the contractor as directed by the engineer.

61. Excavation in excess of the authorized contour will not be paid for unless, in the opinion of the engineer, the conditions are unusual, and the character of the material makes it impracticable to work reasonably close to the specified lines. If, in the opinion of the engineer, the drilling or use of explosives is improperly managed, and unnecessarily shatters the sides or roof of the tunnel, the engineer will have the right to regulate the drilling and use of such explosives.

62. The price paid for tunnel excavation shall embrace all materials between the outer faces of the two portals, and shall include the loosening, loading, transportation and placing of the material in embankment or waste bank as directed by the engineer; it shall also include whatever materials and labor are required for temporary props, supports and scaffolding for the safe prosecution of the work, as well as all expense of keeping the tunnel ventilated and free from water, oil or gas.

63. Niches or recesses for the protection and convenience of the railway employees shall be provided at intervals designated by the engineer.

64. All drainage shall be carefully executed, as shown upon plans, or as may be directed by the engineer, and all springs and sources of water shall be treated as the engineer may direct, the cost of which must be included in the price for excavation.

65. The engineer will determine the location, number and dimensions of all shafts, and the excavation price for them shall cover all materials contained between the surface of the ground and the soffit of the tunnel, within the area of the cross-section specified by the engineer; said price will also cover whatever materials and labor may be required for curbing or such other support as the sides of the shaft may require, the cost of keeping the shafts free of water, as well as the cost of all pumping and hoisting machinery.

66. All necessary wells or sumps shall be made as directed by the engineer, and they shall be paid for at same rate per cubic yard as shaft excavation.

67. The contractor will make all arrangements, and be at the sole expense of any right of way necessary over the top of the tunnel for such roads between the ends of the tunnel as he may need, and all grading necessary for the same will be done at his sole expense.

68. It is distinctly understood that the contract price per cubic yard for tunnel and shaft excavation, respectively, cover any haul found necessary in placing the material where designated, and that there will be no allowance for any so-termed "over-haul."

CLAUSES SPECIALLY APPLICABLE TO REVISION OF EXISTING LINE, AND WIDENING FOR AN ADDITIONAL TRACK.

The contractor must so regulate his methods of work as not to interfere in any manner with the train service of the company, and he will be held responsible for any delays to such service caused by his acts or those of his employees. He will also be held responsible for all damage to existing tracks from such causes. Trains delayed by such acts will be reckoned on a basis of damages, to be charged to the contractor at the rate of $5 for each five minutes of detention of each train delayed. And, further, if continuous detention occur to the train service, the company reserves the right to complete the work, on summary notice to the contractor in writing, at expense of said contractor, as provided for in the contract.

No heavy blasting will be allowed close to the main tracks, nor will the contractor be permitted to transport material, under any circumstances, along or between tracks. Wherever, in the opinion of the engineer, the work is liable to affect the safety of trains, the method of doing such work must first be submitted to said engineer for his approval.

The location of the additional track will generally be on the ..... side of existing line, but whenever it is expedient to change any portion to the ..... side, the altered alinement is shown upon the maps or diagrams attached to and forming part of this specification, and the contractor shall conform to the same without extra charge.

Existing embankments of 4 ft. in height or over shall have the slope deeply plowed in order to bind the new material thoroughly to it.

Wherever it is necessary for material of any description to be transported across the existing track or tracks, the location of the crossings must be approved by the engineer, and the contractor shall furnish at his own cost the lumber and spikes for said crossings. The labor of placing the same will be done by the company, and the actual cost charged to the contractor, and deducted from his estimate.

Watchmen, both day and night, will be put on by the company at all places the engineer considers necessary for the safety of the company's trains and works, and shall be charged to the contractor and deducted from his estimate. It is distinctly understood, however, that the providing of such watchmen shall not relieve the contractor from the liability and payment of damages caused by his operations.

All signals required by the engineer as necessary to ensure the safety of trains consequent upon the contractor's work shall be strictly observed by the contractor upon the whole extent of the work.

GENERAL CONDITIONS.

Previous to or during the work of grading, the contractor may be required to erect and maintain temporary fences, in order to prevent trespass upon the railway or damage to adjoining property.

He shall also make and keep in good condition commodious passing places for public and private roads traversed by the line of railway, and shall be held responsible for damages of whatsoever nature, to persons or neighboring property, caused by workmen in his employ leaving gates or fences open, blasting of rocks, building fires or

other causes, and, if necessary, payment of the engineer's estimate may be withheld at the option of the engineer, until such damages are satisfactorily settled for, the intention of the contract being that the company shall not be held responsible for any claims or losses incurred due to the construction of the line.

The alinement and gradients of the road, as well as ditches, channels, etc., may be changed in manner as the engineer may consider necessary or expedient, either before or after the commencement of the work, and if such change increase the quantities, the contractor shall be paid for such excess at contract rates.

If the alteration diminish the quantities or extent of the work to be done, it shall in no manner be construed as constituting a claim for damages, nor shall any claim be made on the work altered or dispensed with. The contractor shall be paid only for work actually done, at contract rates, except in the case of cuttings and embankments where the slopes had been actually completed and accepted by the engineer; when such have to be altered, the contractor shall be paid for the actual labor of resloping at current rates of wages with 10% added.

Before beginning grading, as well as during the progress of the work, the contractor must remove all snow and ice from between the slope stakes, and at his own expense.

The contractor shall carefully preserve all bench marks and stakes given by the engineer, and in case of neglect to do so, will be charged with the resulting expense.

Whenever required by the engineer, the contractor must open up a safe road for passage on horseback and foot along the whole or any portions of the work under contract.

No allowance or compensation whatever shall be due or paid to the contractor for any temporary roads, bridges or trestles he may make to facilitate the work.

Before the work is finally taken over, the contractor must, at his own expense, clear away from the company's property, as well as from public and private roads, and the channels of streams and ditches, all blasted or excavated material, and all rubbish caused by his employees.

The cost of any extra work will not be considered or allowed, unless such extra work shall have been done by direction in writing of the engineer, and such written directions must in every case contain the rates and methods of payment for said extra work.

The contractor shall take all risks from casualties of every nature, and will not be entitled to any compensation for detentions from such causes.

Whenever the word company is used in this specification it designates the ..... company.

The word "contractor" is used herein to designate the person or persons undertaking the work referred to in this specification and drawings.

Whenever the word "engineer" is used it designates the engineer of the railway company who is in immediate charge of the work, but the directions of any subordinate engineer, in writing or otherwise, shall be obeyed by the contractor, when said subordinate engineer is acting within his regular duties, or is directly transmitting the orders of his superior.

The foregoing specification and general conditions, together with the drawings, are distinctly understood as being embodied with the contract, the whole forming the entire agreement between the company and the contractor.

W. McNab, Asst. Engr., G. T. Ry.; H. J. Slifer, Gen. Supt., C., R. I. & P. Ry.; C. Frank Allen, Prof. of R. R. Eng., Mass. Inst. of Tech.; H. Baldwin, Supt., C. C. C. & St. L. Ry.; R. C. Barnard, Supt., Penn. Lines; A. C. Dennis, Clarksburg, W. Va.; C. Dougherty, Supt., I. C. R. R.; W. D. Pence, Prof. of Civil Eng., Purdue Univ.; H. C. Phillips, Asst. Supt., A., T. & S. F. Ry.; W. F. Tye, Asst. Ch. Engr., Can. Pac. Ry.

A WOODEN CANTILEVER BRIDGE IN INDIA.

The accompanying cut represents a log cantilever bridge near Darjeeling, in the Himalaya mountains of Northwestern India, on the border of Thibet. The cantilevers jut out from anchorage abutments of loose stone and timber. We have no further details of the structure, but it is understood that this design has been in use since a remote period. The view is taken from a photograph presented by Capt. Joseph A. Leonard, late U. S. Consul at Calcutta, to Mr. Horace E. Horton, President of the Chicago Bridge & Iron Works, and we are indebted to Mr. Horton for the opportunity of reproducing it.

It may be noted that this view is one of a series of lantern-slide illustrations presented by Mr. Horton in connection with a lecture delivered on March 12 before the engineering students of the Iowa State College at Ames, Ia.

LOG CANTILEVER BRIDGE NEAR DARJEELING, INDIA.

BLOCK SIGNALING FOR FAST TRAINS.

The March meeting of the Railway Signaling Club was held at Hotel Manhattan, New York, March 10, with some 40 members in attendance. President H. C. Hope read a short address in which he commended recent editorials in the "Railroad Gazette" and Engineering News on the subject of enforcing greater respect for danger signals on the part of enginemen, adding that dishonor as well as dismissal should attach to every infraction of such rules.

Mr. H. M. Sperry then took up the subject of Block Signaling for Fast Trains. He propounded a series of topical questions for discussion, as follows:

1. Our present method, particularly in automatic block systems, is to omit the overlap where the distant signal is provided. Would it not be an advantage to employ both the distant signal and the overlap?
2. Should we consider the use of the following adjuncts?
(a) Automatic stops—and can they be arranged to meet all the operating conditions of two and four-track railroads?
(b) Should they be placed on the surface or overhead?
(c) If operated by an electric current, what would be the effect if the current fails?
3. Audibile signals to repeat the visual signals—
(a) Of what type—torpedo, whistle or bell?
4. Are indicators in the engine cab, to repeat the position of the outdoor visual signal, desirable?
(a) Of what form should they be?
(b) Can such indicators be used without the outdoor signals?
5. What attention are we giving to the uniform location of signals so that the governing signal can always be found on the right of the direction of traffic, and next to, or over, the track it governs?
6. Is the use of green for the safety indication meeting with favor?
7. Can anything be done in the direction of reducing the number of high signals, by the use of low or dwarf signals for slow speed diverging routes?
8. In the preparation of time-tables, what consideration is given to the block signal capacity of the line?

The questions were discussed in an informal way, Mr. Sperry opening and closing the discussion, but so much time was given to the first question that little or no discussion was had upon some of those following. Mr. Sperry maintained that the overlap is essential, and that in England, where it is often said that an overlap is not used, one is used in effect, for a train is not allowed to enter a block until the train in front has passed out of that block and has run some distance. Mr. H. Raynar Wilson gave this distance at 300 to 400 yds.

A letter was read from Mr. W. H. Elliott stating that on the Chicago, Milwaukee & St. Paul the overlap has been in use since the first installation of automatic signals, and the company is well satisfied that it is worth the additional cost. Near a large terminal provided with no distant signals the overlap is made 1,500 ft.; with automatic block sections, provided with distant signals, the overlap is 1,000 ft., except where the blocks are less than 1.5 miles long, when the overlap is 600 ft.

Mr. Sperry said that of course the length of the overlap should depend upon the speed of trains and the grade, to which reply was made that all trains have not the same speed on the same road, thus multiplying difficulties where the overlap is used.

Past-President Rosenberg came out strongly against any overlap, arguing that if an engineman would run by one signal he would run by a second signal. On his road, to run by a signal means instant discharge—not a lay-off or a fine. In one case the engine had run by a signal only a few feet due to slipping of wheels on the rails, nevertheless the engineman kept on "slipping" until he slipped out of his cab and he never slipped back again. Replying to a query as to how infractions of rules were to be detected, Mr. Rosenberg replied that he preferred not to make public the methods adopted to detect disobedience or carelessness—but that there are ways of doing it. He objected to the frequent stoppage of trains where overlaps are used, and the resulting liability of breaking heavy trains in two. One signal, he said, is as good as two and the engine-driver should know exactly where that one is, and be ready to stop there.

Mr. Ten Eyck, of the New York Central, brought out the point that with blocks three miles long, provided with a distant signal 2,000 ft. away, and an overlap of 1,000 ft. more, trains would be kept too far apart on a road of heavy traffic.

Mr. Sperry, in closing the discussion, said that if trains can be stopped exactly where it is wished, by force of discipline, then the overlap is not needed, but he evidently did not believe that this could be done. It was then moved that the overlap is not needed where a distant signal is used, and this motion was carried by a vote of 22 to 5.

The discussion of Mr. Sperry's second question was regrettably brief, and practically confined to the remarks made by Mr. Kinsman, the inventor of an automatic stop device. He argued that every man's mind at one time or another reaches a dead center, and he is powerless to act at once, hence the desirability of some mechanical automatic device to shut off steam and apply brakes. His experiments had led him to abandon any tripping arrangement operated by the wheels or other part of the locomotive, and to employ an electric device not affected by snow or weather, and not coming in contact with the locomotive. Mr. Wilson replied that the cost of automatic stops would make their use prohibitive, and that greater discipline would secure immunity from accidents, as witnessed by the almost entire absence

of accidents in England due to overrunning a signal.

Upon motion the President was empowered to appoint a committee of five to investigate the subject of automatic stops. Another committee of five is also to take up the question of disciplining enginemen, and to ascertain whether inspectors of enginemen's conduct make formal written reports.

The third question, relating to audible signals, was next taken up. It was stated that torpedoes used in the Fourth Ave. tunnel, New York city, are satisfactory; but bells are not readily heard by the engineman, although distinctly audible to passengers. Mr. H. Raynar Wilson agreed to write a paper to be submitted at the next meeting of the Club, giving the practice in England as regards audible signals. He said that for two or three years the locomotives of the North Eastern of England have been equipped with Raven's fog whistle, but it had not yet had time to fully show its merits.

The fourth question was not discussed, but some time was given to the fifth question relating to uniform location of signals. Mr. Ten Eyck gave the practice of the New York Central on its four-track road. Bridge signals are being removed as they wear out, and are replaced by straight post and bracket signals. The two outer tracks are used by eastbound trains and the two inner tracks by westbound trains. The straight-post signals govern the outer tracks, and the bracket-post signals govern the inner tracks, a dummy-doll being placed on the bracket to educate the engineman to look for the signal nearest his track. It is true that by this method an engineman must look to the left for his signals on one trip and to the right on the return trip, but in practice this works well and all enginemen favor it; whereas, enginemen complain that the two bridge lights over the middle tracks are confusing when one of those lights is out.

The discussion of the sixth question was brief, but showed unanimous approval of the use of green as a safety indication. There was practically no discussion of the last two questions.

THE ELECTRO-MAGNETIC TRACK BRAKE.*

By R. A. Parke.†

The application of other forms of power than compressed air to brake-service has been practically limited to the vacuum and electricity. The limited pressure and the bulky apparatus required have restricted the use of the vacuum to comparatively light vehicles and it is fast becoming a mere historical feature of the development of the art of braking. Electricity has been experimentally applied in various forms of apparatus, but has only recently become recognized as a means of promising utility in practical braking. The simplicity of employing the back torque of the car motors of electric railroads for retarding purposes has appeared very attractive to those unacquainted with the objection to dependence upon that means alone. In combination with other means of retardation, so that excessive heating may be avoided, this means of braking cars has been used with some practical success. But the application of electricity to the purpose of braking that appears to overshadow all others is the magnetic brake, which embodies such novel applications of old devices, with results so phenomenal, that the use of electricity as the source of braking force in electric railroad service at once occupies an interesting position with a very promising future.

The magnetic‡ brake forms part of a combined braking and car-heating system; in the latter the diverters of the ordinary car-starting apparatus are also used as resistances for grading the current employed for braking purposes, and are arranged to serve as car-heaters. This part of the system is itself of such interest that, while it is a separate purpose, a brief description is excusable.

It appears to be a well-established fact that under the usual conditions of service the heating effect due to the use of resistances in starting an electric car is not sufficient, by itself, for the practical purpose of heating the car; but when, in addition, the heating effect accompanying braking is also used for that purpose, the heat supply is abundant. Two systems of resistances are therefore used, one beneath the car, radiating the heat into the external atmosphere, and the other suitably arranged within the car for heating purposes and called heaters. The two systems may be so combined, according to the temperature and weather that any desired portion of the generated heat, from none to all, may be employed for heating the car, the remainder being dissipated. The heat supply is, of course, intermittent, but the heaters used have a large heat storage capacity, so that they readily absorb the intermittently generated heat, and gradually and continuously supply it to the car for uniform heating. In this manner the cost of the trolley current ordinarily required for heating purposes—an item of no mean proportions—is saved.

The brake apparatus itself consists of a combination of a track-brake with the ordinary wheel-brake. Track-brakes have long been known and variously proposed for practical use, but no satisfactory application of these devices appears to have been made. The track-brake consists of a system of brake-shoes, arranged beneath the car, directly over the rails, which may be forced down upon the rails to produce the retarding friction. There are several serious obstacles to the attainment of satisfactory efficiency from this method of retardation. In the first place, as the weight of the car must be lifted off from the wheels and transferred to the track-brake shoes, it is obvious that the shoes must be so formed that they will guide the car upon the rails as safely and surely as do the wheels. This appears to be impracticable and, in the cases where the track-brake has been employed in the past, only so much of the weight of the car is transferred to the brake-shoes that there still rests upon the wheels sufficient weight to enable them to guide the car securely. Thus only a portion of the weight of the car is available for rail friction.* Again, it is manifest that the friction of the track-brake shoes is of the same dynamic character as that of the brake-shoes upon wheels, which varies inversely with the speed; and is very much inferior to the static friction of the rotating wheels upon the rails, which

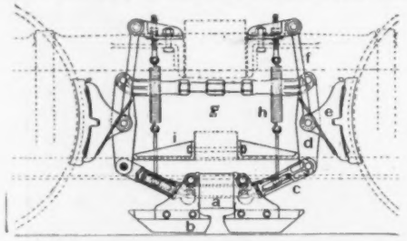

Fig. 1. Elevation of Electro-Magnetic Brake as Applied to Four-Wheel Truck.

is the measure of the available friction of brake-shoes upon the wheels. While it is undoubtedly true that the large area of contact between the rails and track-brake shoes that may be employed results in a track-brake friction which is much superior to that of the sliding wheels (provided the entire weight is transferred to the track-brake shoes), it is doubtful if the conditions permit the realization of as high a coefficient of friction where brake-shoes rub upon the track as where they are applied with the same force to the wheels.

Thus, the combination of a track-brake of this kind with a wheel-brake is merely an added intricacy, as the efficiency of the track-brake is entirely at the expense of the wheel-brake, in robbing the latter of the rail friction upon which its effectiveness depends. For these reasons, and for the additional one of constructive complication and cost, no practical application of the track-brake has ever been made, within the knowledge of the writer, except in certain cases of street railroads with exceptionally heavy grades, where an independent track-brake system has been installed for emergency use only, in the event that the wheel-brake system should become disabled.

But the magnetic track-brake introduces an entirely new element, through which the track-brake does not interfere with the efficiency of the wheel-brake but both adds to its normal retardation and provides the operating brake force. The track brake-shoe is placed between the two pairs of wheels, and, instead of being forced upon the rails through an effort from the car, is drawn to the rails by an electromagnet suspended from the car, thereby not merely adding its friction to the unimpaired friction of the wheel-brake but also actually increasing the rail pressure of the wheels to the extent that the supporting springs for the track-shoes and magnets are in tension through the descent of the track-shoes to the rails. The construction will be better understood by reference to the accompanying illustration, Fig. 1.

In Fig. 1 the magnetic brake apparatus is shown as applied to a four-wheeled swiveling truck, the parts of which are in dotted lines, more readily to distinguish the brake apparatus. The electromagnet a, dividing the track-brake shoe b into two parts, is secured by pins to the two push-rods c, and suspended at a proper distance above the rails by the adjustable springs h. The push-rods are secured by pins to the lower ends of the brake levers d, which are connected at their upper ends by the adjustable rod g and are pivoted at an intermediate point to the brake-shoe holders e, carrying the wheel-brake shoes, and the hanger-links f, suspended from the truck-frame. The push-rods c are telescopic, as shown in the sectional view of the one at the left, so that a movement of the track-shoe toward the right, relative to the truck-frame, causes the wheel-brake shoe at the right to be applied to the wheel and the connection g to be moved to the left, thereby applying the wheel brake-shoe at the left, the stop i preventing the lower end of the brake lever at the left from following the track-brake shoe. A relative movement of the track-brake shoe to the left is obviously accompanied by application of the wheel-brake shoes through corresponding movements of the parts in the reverse order.

The brake-controlling device may be incorporated in the running controller or may be a separate device, placed by its side and operatively interlocked with it, so that neither can, through carelessness, be caused to interfere with the operation of the other.

(A separate brake controller and its connections to the car motors and the heaters are shown in Fig. 2, taken from the catalogue of the Standard Traction Brake Co., of Pittsburg, Pa.)

In the operation of the apparatus the current for energizing the brake magnets is supplied by the motors, running in multiple as generators, and is divided between the electromagnets and the diverters in such ratio as to cause the track-brake shoes to be drawn upon the rails with a force proportionate to the braking requirements. The frictional resistance of the rails to the motion of the track-shoes causes the wheel-brakes to be applied with corresponding force. Thus, to the ordinary retardation of the wheel-brakes is added that of the track-brake and also the back torque of the motors, which, however, is practically limited to compensation for the rotative energy of the motor and car wheels. The force of application depends primarily upon the current and upon the electromagnets operating the brake-shoes. The attractive force of the rails upon the magnets is under the control of the motorman up to a limit of about 150 lbs. per sq. in. of brake-shoe surface in contact with the rails. The strength of the magnet is limited by the sectional area of the rail, acting as armature to the magnet, and where the weight of the car makes a magnet of greater strength desirable, the track-shoe is divided into three parts instead of two, and is wound to form a three-pole magnet, or two electromagnets with one common pole.

The friction of the track brake shoe may also be adjusted to some extent through the angular inclination of the push rods c, by which some of the weight of the car may be thrown upon the track-shoes, the levers d being correspondingly adjusted to reduce the wheel brake-shoe pressure in proportion as the weight is transferred to the track-shoe. It will be observed also that the brake-shoes are hung at the inside of the wheels so that the hanger links may have an angular inclination to correspond with the transfer of weight from the rear to the forward pair of wheels through the influence of the retarding forces.

The incidental features of the magnetic brake are also of interest and great value. The braking current declines with the speed while coming to a stop, thereby offsetting the increased coefficient of friction at the lower speeds. In bad weather, when the rails are in slippery condition so that the wheels are liable to slide if full pressure is applied to the brake-shoes, the pressure from the track brake on the wheel brake is correspondingly reduced so that the force of application of the wheel-brake is automatically proportioned to the rail friction which rotates the wheels. But, in addition to this valuable feature, if

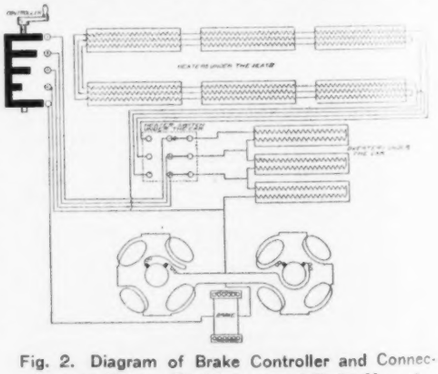

Fig. 2. Diagram of Brake Controller and Connections to Motors, Resistances and Brake Magnet.

by chance the wheels should slide upon the rails, the interruption of wheel rotation is accompanied by the extinguishment of the track-magnet current, through which the pressure of the brake-shoes upon the wheel is instantly relaxed and rotation of the wheels is resumed, without injury or serious loss of time.

In operation the efficiency of the magnetic brake under the various conditions of service is phenomenal and far exceeds that of any other braking system for the retardation of trains. This fact, combined with the commercial advantage of dispensing with the use of trolley current or any other means for heating cars, seems to assure it a leading position in electric railroad operation in the future.

*Extract from a paper on "Railroad-Car Braking" read before the American Institute of Electrical Engineers on Dec. 19, 1902.

†Mechanical Engineer, Westinghouse Air Brake Co., 26 Cortlandt St., New York City.

‡The invention of Mr. F. C. Newell, of Chicago, Ill.

*In one or two cases the track-brakes have been arranged to grip the head of the rail (T-rail) by two lateral jaws. The above objections would not apply to such an arrangement.—Ed.

A WATER ARCH FOR LOCOMOTIVE FIREBOXES; MONTANA CENTRAL RY.

An interesting experiment in locomotive construction which is now being tried on the Great Northern Ry. consists in the application of a water arch to the firebox, in place of the ordinary firebrick arch. The results thus far obtained are said to be very satisfactory in regard to reduction in fuel consumption, in boiler washing and repairs, and in the amount of scale.

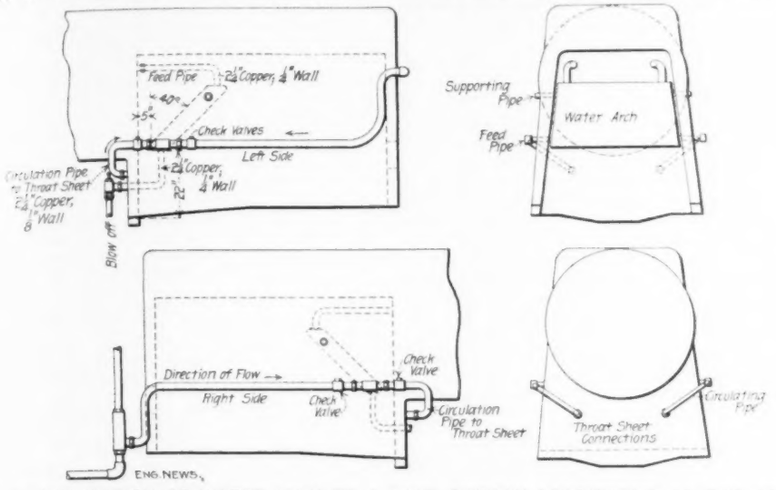

FIG. 1. APPLICATION OF WATER ARCH TO A WIDE FIREBOX LOCOMOTIVE OF THE GREAT NORTHERN RY.

The arch consists of a steel box about 6 ins. wide and 3 ft. long, but of varying size and shape to fit different styles of fireboxes. It is built up of ⅜-in. plates, riveted together, and is strengthened by through staybolts. This box is fitted between the side plates of the firebox in an inclined position, with its lower end close to the tube plate, being supported at each side by two pieces of 2¼-in. steel pipe which pass through the side water spaces of the firebox by means of thimbles. The feed pipes from the injectors are connected to the two lower supporting pipes, the water rising through the arch, and then into two 2¼-in. copper pipes at the top which discharge into the boiler. These copper pipes are ¼-in. thick, and connections are made with union ball joints.

The water arch not only serves to divert the flame and gases from passing directly to the tubes, but also acts as a feed water heater and scale trap. The water from the feed pipe is not delivered immediately to the boiler but remains practically quiescent in the water arch, where the heat and stillness combine to cause mud and scale-producing matter to settle to the bottom of the arch, whence it is blown off as required while the engine is running. To prevent burning of the plates of the arch through lack of circulation when the injector is shut off, an automatic circulating valve is used, in a pipe connecting the front water space of the firebox with the bottom of the arch. While the injector is working, the pressure in the arch keeps the valve closed, but when the injector stops, the pressure of water in the boiler opens the valve. In this way a continuous and uniform circulation is maintained, which is said to have an important effect in checking contraction and expansion, with the result of greatly reducing trouble from broken staybolts, leaky tubes and crown stays, and cracked side plates.

Fig. 1 shows the application of the water arch and pipe connections to a Pacific type engine with wide firebox on the Great Northern Ry. This is not drawn to scale. Fig. 2 shows the details of construction of an arch for a radial stayed firebox, and also the method of supporting it in place. This water arch is the invention of Mr. A. E. Taber, Master Mechanic of the Montana Central Ry. (Great Northern Ry. system), and we give below his statement in explanation of the device and the results of practical experience with its use.

The results gained by the use of the water arch on the Montana Central Ry. are that we have shown a saving of between 15 and 25% in fuel, and the boiler repairs to engines so equipped are practically nothing. Engines that have given a great deal of trouble, due to leaky flues, stay and crown bolts, have caused no trouble after the water arch was applied. We now have four engines so equipped on the Montana Central Ry., and they are all giving about the same results. We have one working in a very bad water district on the Montana Division of the Great Northern Ry. This has now made something over 4,000 miles without requiring the boiler washed out, or boiler work of any description, although engines not so equipped working on the same district are washed out after making 150 miles, and cause a great deal of trouble on account of leaky flues, etc. We have just installed two more on the Dakota Division of the Great Northern Ry. This is another of the bad water districts, and although engines have not as yet been in service long enough to obtain reports, I feel safe in saying that they will give equally as good results on that district as they have on others, and I look for a better showing in coal, due to the fact that a better quality of coal is used on the eastern districts of the Great Northern Ry. than is used on the western districts.

Engine No. 601, on the Montana Central Ry., is equipped with this arrangement, having been equipped Dec. 10, 1901. In making over 50,000 miles in freight service, it has had the boiler washed out three times. Even after making 12,000 miles, scarcely any mud was found, except on the mud ring, where there was about 1½ ins. of mud and loose scale, all other parts of the boiler and water arch being perfectly clean. After the boiler had run 12,000 miles without being washed out, I made a personal inspection of the boiler with the above results.

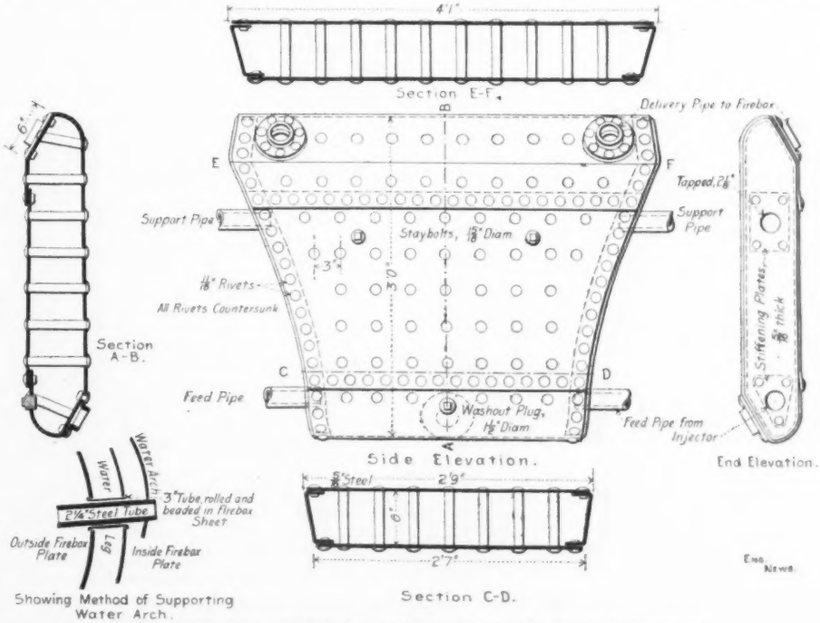

FIG. 2. DETAILS OF WATER ARCH FOR LOCOMOTIVE FIREBOXES.
A. E. Taber, Master Mechanic, Montana Central Ry., Inventor.

HOW TO OBTAIN AND CARE FOR DRIVEN WELL WATER SUPPLIES.*

By George Bowers,† M. Am. Soc. C. E.

The location (of driven wells.—Ed.) should be left to the geologist and the expert when possible. When this is decided, the engineer's work begins. For one thing, he must see that no sewage is allowed to flow on the land used for the water supply, as any risk of contamination should be avoided. The land may be cultivated if it is thought advisable, but care must be taken in the selection of fertilizers used. After the location has been selected comes the sinking of the wells. The particular kind of well used depends upon the coarseness of the sand or gravel found; if it is fine a screen must be used which has a correspondingly fine mesh, but if the well is sunk in gravel an open-end pipe may be used.

To obtain water that is entirely free from sand it is absolutely necessary that the well should be thoroughly made, and all the fine sand around the screen removed, then when it is connected with a group and pumped by steam the result should be a perfectly clear water.

A system of wells requires care as does anything that is expected to produce first-class results. Every well should be provided with a gate by which it may be shut off from the rest, and with a cap so that it may be opened, examined and cleaned. Every well in use should be opened and thoroughly cleaned at least once a year, and the sand and gravel surrounding the openings or strainers should also be cleaned, and the very fine sand removed. When the well is first opened it should be pumped and the yield per minute recorded; it should then be cleaned as stated and pumped until the water is perfectly clear. It should then be tested and the yield taken for the yearly record.

After an experience of ten years the speaker believes that when a well is properly made and rightly cared for it will continue (the conditions being the same) to yield its original amount of water, if indeed it does not exceed it.

You should not place much confidence in people who tell you that they once had some very good wells, but that in a few years after they were driven the volume of water decreased so much that they were obliged to abandon them. If this matter were looked into carefully it would be found that the wells were simply left to take care of themselves, or else were not properly pumped. As an illustration of this; a small manufacturing company had a good well; it was 2-in. pipe, driven 50 ft., and had a few small holes drilled in the side near the bottom, and the bottom left open. For several years the well supplied al the water needed, but as the company prospered and enlarged its business more water was required and the engineer was obliged to pump so much from the well that it gradually drew sand and gravel into it, and instead of getting more water, they got less and less, until they gave the well up entirely. Upon investigation the speaker found that the well would yield 50 gallons per minute,

*Abstract of a paper read before the New England Water-Works Association, March 11, 1903. The paper in full will be printed in the Journal of the Association.

†City Engineer, Lowell, Mass.

but in forcing it beyond its natural capacity and trying to make it a 75-gallon well they ruined it.

When pumping, if only a small amount of water is required the pumps may be run as is most convenient, but if a large amount of water is required, or if you wish to obtain all the water possible, it is better to pump the wells continuously and keep the water in the ground moving towards them than it is to stop pumping and thus allow the current of water to change its direction.

This former method is the one adopted in Lowell, and we feel well satisfied with the result. The speaker read a paper before this Association five years ago which closed with the following statement: "The quality of the water has from the first been excellent and now that the quantity is assured I think we may be entirely satisfied with the result of tube well experiments in Lowell." This statement is as true to-day as it was the day on which it was made. We have an abundant supply of water, our wells yielding as much as when first driven. This latter fact is, of course, due in a large measure to the care they have received. It goes without saying that they have always been well looked after, as our Superintendent, Mr. Thomas, is well known to you all as a man who allows nothing to escape his attention, and who is thoroughly interested in the driven wells, which are entirely under his supervision.

The opinion of the speaker is that if the state would employ a first-class geologist, to whom its cities and towns might apply for advice when looking for ground water, it would prevent a great waste of both time and money. The need of a thorough knowledge of the geology of the state is appreciated more and more as the subject of underground water supply is given more attention.

The speaker wishes to call your attention to the fact that but one folio of the U. S. Geological Survey showing the areal underground structure of Massachusetts has ever been published, and this covers the region about Holyoke only. Another folio nearly completed is the Housatonic quadrangle, which takes in the southwestern part of Massachusetts and a little of New York and Connecticut. If the survey of New England were made and published it would be a great benefit to us all, and if the members of this association would interest their representatives to Congress in this matter there is no doubt but the work in this section of the country might be hastened.

A NEW TYPE OF DREDGING PUMP.

In pumping water containing sand or other gritty material the grit rapidly cuts the cylinder and the packing rings of a plunger pump.

We show, in the accompanying cut a plunger pump designed for dredging use with a special view to reducing the wear of parts by the grit in the water. A pair of plungers, G G, are driven by a walking beam. During the upper stroke of either plunger, a valve, W, opens, admitting water, sand and gravel into the conical chamber H which is full of water. The downward stroke of the plunger forces this water and sand through the pipe into the middle chamber, H, which acts as a reservoir furnishing a regular supply to the delivery pipe J¹, whence it passes to the point of delivery.

Through a small clear-water feed-pipe L, clean water is drawn into an annular chamber, Z, surrounding the plunger just below the packing.

This clear water, escaping through holes in the annular chamber and impinging upon the plunger, washes it clean at each stroke, thereby preventing any grit from cutting either the plunger or the packing rings.

Any air that escapes from the water in the chamber H, passes through the valve M into the middle chamber H¹, the upper part of which chamber acts as an air cushion for the pump.

The apparatus was invented especially for use in gold dredging, for which purpose the plunger pump as here illustrated is claimed to have numerous advantages over the centrifugal pump. The invention is controlled by the Bewsher Sand Pump & Dredging Co., of 111 Cedar St., New York city. A small exhibition pump has been set up by the company in New York city, and was recently visited by a number of the staff of this journal. Tests made at his request resulted in a delivery of 9¼ lbs. of moist sand in 21¾ lbs. of mixed sand and water pumped as an average of several tests. The plungers of this pump are said to have been in use for a long time and show no sign of wear. We are also informed that a large sized pump of this type was used for some time by the inventor in dredging sand from a river bed in Oregon and the device above described proved successful in preventing wear.

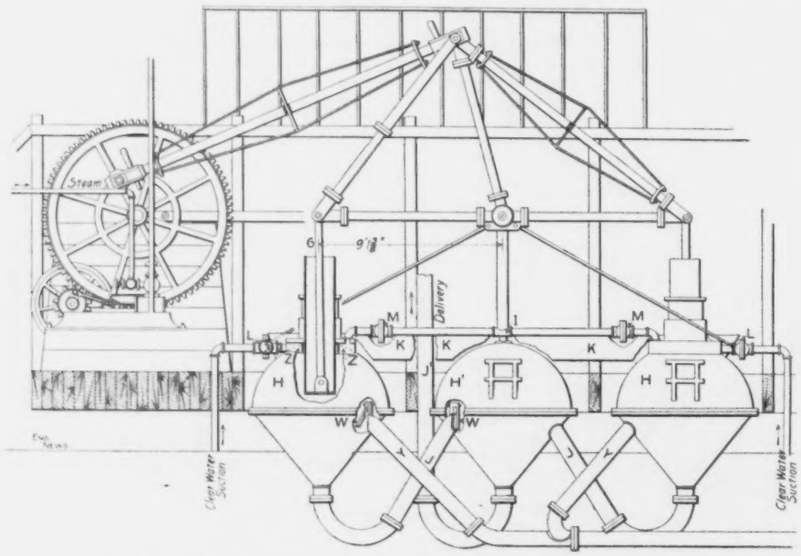

FIG. 1. A NEW TYPE OF PUMP FOR DREDGING AND PUMPING GRITTY WATER.

IMPENDING CHANGES IN THE FOUNDRY INDUSTRY.*

By Dr. Richard Moldenke,† M. Am. Inst., Min. E.

The eight-hour day has long been demanded, and I predict that it will come. Whether it will bring disaster to our industry, or will find us prepared to balance matters by suitable changes in our running methods, may well be worth our careful attention. Personally, as a trained mining engineer, I favor the eight-hour day, but—we must have three of these short days in every 24 hours. The wise king, who held that eight hours were for work, eight for sleep, and eight for recreation, was perfectly right. It took many centuries to come near his ideal, but it will not be many more years before this is attained. However, if labor is to receive high returns for short hours, capital is no less entitled to take as heavy an income as these highly-paid short hours can be made to yield. When I say that capital invested in the foundry should yield interest for 22½ hours out of the 24, nearly every foundryman will throw up his hands and say, impossible! And yet this is exactly what many of them will have to arrange for or go out of business.

Do you note the general inquiry with reference to running the cupola continuously? You may not be aware that many foundries are already running two shifts and could easily arrange for three if there were molders enough available. The arbitrary arrangement of the apprentice question is bound to take a fall in the near future, and molders, good ones and plenty, will take work where it is offered. The solution of the whole future of the foundry lies in the molding machine and men with better all-around foundry education.

Probably nine founders out of ten will tell you that night work is no good. I have never found this to be the case, but always enjoyed the sight of floor upon floor of molds ready to pour the first thing in the morning. With plants as light at night as in the day time, with proper organization, and short hours instead of the usual eleven-hour night shifts, wonders of work can be accomplished.

That this is not theoretical may be seen from the actual fact that in the lumber industry the night gang is always able to turn out more material than the day men, hour for hour. There is not the necessity to take in dog fights, gossiping, and the like, which is very detrimental to a continuous and strenuous output. In the mines, where it is night all the time, no difference in the rate of production is noticed, and here we find a little point which is of value to the foundry. One of the chief interferences with effective night work is the objection that molders on four or five day molding jobs have to letting others continue their operations. Suppose now, that the half dozen men who would be involved were given a contract to turn out the job properly, this difficulty would fall away at once, for no one has yet seen competent and friendly molders refuse to pound the sand together on the same mold. This is what we find in the mines. The particular stope may have two or three parties of men at work at the same time alternately. At a stated period their stope is measured up by the captain or engineer and a lump sum, as per contract, is handed out.

Why can this not be arranged for in the foundry? Does it come under the ban of piece work? If so, the sooner it is straightened out the better, and many a foundry can turn out 50% more work for the same floor space.

The only other objection of account we meet—that molders want to pour their own molds—is cared for by continuous pouring.

Now I predict that something along these lines will come soonor or later, and if the foundry industry, which is looking very closely into the recent experiments with double turns, is sufficiently alert, the coming eight-hour day need not be feared very much.

We not only build immense plants. We are enlarging the old ones to an extent which really means further immense plants. We have them full of to-day, and nearly deserted to-morrow. This is not political economy, and means that when the hard times do hit us, that we take work at less than cost, to keep our organizations. Many a nice fat surplus is wiped out in the hard times. This is not right, and perhaps the three eight-hour shifts mentioned above may help to solve the difficulty in a measure, for a smaller plant will do for the normal output, a tightening up of conditions is met with by cutting out one shift, and hard times with one turn, or even less, at work, where otherwise a vast establishment will run short handed three days a week.

Already we have some 9½ hours only of the 24 put in at actual production, the balance of the day sees the machinery idle, while the company's notes are piling up interest. With the eight-hour day things will be worse unless steps, such as I have indicated, are resorted to. We would therefore see a plant necessarily three times as great in the lay-out as need be, and practically three times the capital tied up in it, two-thirds of which is doing nothing, in fact costing interest. What could not be done with this vast amount to enrich our great nation still further?

*Extract from a paper in the "Journal of the American Foundrymen's Association."

†Consulting Metallurgist, P. O. Box 432, New York city.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF MICHIGAN.—The engineering department is making more rapid gains in the number of students than any other department of the University. There are now 600 students in engineering courses, which is a gain of 20% over last year.

SYRACUSE UNIVERSITY.—The College of Applied Science of this institution offers courses in Civil Engineering, Electrical Engineering and Mechanical Engineering. This has been made possible by the generosity of a citizen of Syracuse, Mr. Lyman Cornelius Smith, the manufacturer of the Smith Premier typewriter. An elegant stone building has been erected on the campus, to be followed by others.

PURDUE UNIVERSITY.—The State Legislature has appropriated $150,000 for the University, out of which appropriation a building for the department of physics and a central heating plant are to be provided. By an amendment of a previously-existing law the income of the University has been increased from 1-20-mill to 1-10-mill upon the assessed value of the state, which increase adds $55,000 to the annual income, making the total income in excess of $200,000.